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JAMES TUCKER
Lead Counsel
jtucker@idahopower.com

July 29, 2016

John Tippetts, Director
Idaho Department of Environmental Quality
1410 North Hilton
Boise, Idaho 83706

Pete Shepherd, Interim Director
Oregon Department of Environmental Quality
811 SW Sixth Avenue
Portland, Oregon 97204-1390

Re: Idaho Power Company, Hells Canyon Complex (HCC)
FERC Project No 1971
Application for Certification – Clean Water Act § 401

The Idaho Power Company (IPC) is withdrawing its pending CWA Section 401 Certification Application, dated December 1, 2015 and, on this date, contemporaneously filing a new *Section 401 Water Quality Certification Application (Application)* together with an *Addendum to Idaho Power Company's Water Quality Certification Application (Addendum).*[1] In June 2016, the Oregon Department of Environmental Quality (ODEQ) sent IPC an additional information request (AIR) asking IPC to provide documentation that describes how the proposed Snake River Stewardship Program (SRSP) and the Riverside Operational Water-Quality Improvement Project (ROWQI) meet the requirements of Oregon's recently enacted water quality trading rules, OAR 340-039-0025.[2] In response to that AIR, IPC, working with The Freshwater Trust, prepared a "crosswalk" that demonstrates that the SRSP and ROWQI are fully consistent with the Oregon and Idaho water quality standards, the SR-HC TMDL,

[1] The new *Application* and *Addendum* may be accessed by the DEQs through a secure FTP site, instructions on access to the site will be provided by separate email. A copy of the *Addendum* is also included with this correspondence. The *Addendum* contains the only new information submitted with this *Application*. Access to the new *Application* and *Addendum* will also be available through the IPC website (www.idahopower.com) within the next two weeks.

[2] A copy of the AIR is attached.

P.O. Box 70 (83707)
1221 W. Idaho St.
Boise, ID 83702

and any applicable water quality trading rules and guidelines. This information is in included in the *Addendum* to the *Application*.[3] The *Application* contains no new data or information.

ODEQ requested that IPC withdraw and refile the Application, with the new information in response to the June AIR, in order to provide ODEQ with additional time to consider and evaluate IPC's response. ODEQ and the Idaho Department of Environmental Quality (IDEQ) have advised that if the Application is withdrawn and refiled, that the DEQs will make a good faith effort to issue a proposed 401 certification for public comment not later than 90 days after the date that IPC provides a response to the AIR and to thereafter review any public comments and issue a final 401 certification decision not later than 120 days after the close of the public comment period. It is on the basis of that representation that IPC is withdrawing the previous 401 Application and submitting the new *Application* and *Addendum*.

Oregon also requested that IPC withdraw and refile the previous 401 Application to allow for discussions between Oregon, Idaho and IPC to continue with regard to issues associated with the potential passage and reintroduction of anadromous fish in Oregon tributaries above Hells Canyon Dam. IPC does not consider these issues to be either relevant to or appropriate considerations for Section 401 of the Clean Water Act. These issues were not addressed in any of the previous fifteen (15) Section 401 Applications filed with Oregon and Idaho since 2003 and they are not addressed in this *Application*. Notwithstanding, IPC has participated in recent discussions with Oregon and Idaho in an effort to reach a settlement agreement on these issues outside of the 401 process. However, because the passage and reintroduction of anadromous fish on a border river such as the Snake River not only implicates species protected under the Endangered Species Act but also the waters of Idaho and Oregon, IPC has been clear in these discussions that it cannot enter into a settlement agreement on these issues in the absence of consensus between Oregon, Idaho and the applicable federal resource agencies <u>and</u> the subsequent approval of the agreement by the Federal Energy Regulatory Commission (FERC). Recently, by letter dated July 19, 2016, Governor Otter of Idaho advised Governor Brown of Oregon that Idaho "cannot and will not, agree to the reintroduction of salmon and steelhead above Hells Canyon Dam"[4]. In light of what appears to be an impasse between Idaho and Oregon on issues associated with the potential passage and reintroduction of anadromous fish above Hells Canyon Dam, IPC will not participate in further settlement discussions relative to these issues in the absence of being invited by both states to reconvene such discussions.

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[3] Also consolidated in the *Addendum* are Idaho Power's responses to the AIRs submitted by ODEQ on April 5, 2016 and January 2016. These responses have previously been submitted to ODEQ and are included in the *Addendum* for ease of reference.

[4] A copy of Governor Otter's letter is attached.

IPC continues to appreciate the input and cooperation of IDEQ and ODEQ staff in the 401 certification process. Please let us know if there are questions relating to the *Application* or the *Addendum*.

Sincerely,

James Tucker
Lead Counsel

cc: ODEQ/E. Nigg, M. Fonseca, A. Marriott
IDEQ/B. Burnell, D. Conde
NOAA Fisheries
USFWS
Oregon Governor's Office/R. Whitman
Idaho Governor's Office/S. Goodson
Idaho Office of Species Conservation/D. Miller
FERC

-----Original Message-----
From: FONSECA Marilyn [marilyn.fonseca@state.or.us]
Sent: Wednesday, June 29, 2016 11:11 AM Mountain Standard Time
To: Randolph, Chris
Cc: Barry.burnell@deq.idaho.gov; 'Douglas.Conde@deq.idaho.gov'; NIGG Eric; FONSECA Marilyn; GARRAHAN Paul
Subject: [EXTERNAL] additional information request

Good morning Chris - ODEQ staff continues to review the December 1, 2015 application for §401 certification for the Hells Canyon Complex. As noted in the June 7, 2016 call between Jim Tucker, IPC and Eric Nigg, ODEQ, ODEQ has determined that the Snake River Stewardship Program (SRSP) and the Riverside Operational Water-Quality Improvement Project (ROWQI) fall under Oregon's Water Quality trading rules.

The trading rules are contained in Oregon Administrative Rules (OAR) 340-039-0001 through OAR 340-039-0043. Please provide documentation that describes how the SRSP and the ROWQI meet the requirements of a water quality trading plan, as described in OAR 340-039-0025. The documentation may be submitted as an addendum to the December 1, 2015 application for §401 certification which cross references the SRSP and the ROWQI with the trading plan requirements .

Please provide the information by July 8, 2016. If IPC is unable to provide the materials by this date, please provide DEQ with the date IPC can complete the request.

Thank you,

Marilyn Fonseca
Oregon Department of Environmental Quality
811 SW 6th Avenue
Portland, OR 97204
(503) 229-6804

C.L. "BUTCH" OTTER
GOVERNOR

July 19, 2016

Honorable Kate Brown
State Capitol Building
900 Court Street NE, 160
Salem, OR 97301

Dear Governor Brown,

As you know, Idaho Power is currently seeking renewal of its federal license authorizing the operation of their hydroelectric dams within Hells Canyon. This process has been going on for over a decade, and we are eager to conclude this process so that ratepayers in Idaho and Oregon can continue to receive affordable, clean power.

Because these dams on the Snake River span our two states, Idaho and Oregon must certify that Idaho Power's operations comply with each states' respective water quality standards. In conjunction with the Oregon certification process, your office approached Idaho Power and members of my staff regarding the possibility of reintroducing salmon and steelhead into certain tributaries above Hells Canyon Dam, namely Pine Creek. It has been represented that Oregon would prefer to enter into an agreement with Idaho Power and the state of Idaho to implement a phased approach wherein Pine Creek would be evaluated for its potential to support populations of salmon and steelhead. And, if the habitat potential is determined to exist, Oregon would proceed with full-scale reintroduction of chinook salmon and steelhead into Pine Creek.

Idaho cannot agree to this approach. While I appreciate Oregon's willingness to limit these reintroductions to Oregon tributaries, the agreement would result in reintroduced fish entering Idaho waters. Such occurrence would violate long-standing Idaho law and policy opposing reintroduction of any species without the express consent of the Idaho State Legislature and executive branch.[1] Based on state law and in part on our past experiences with reintroduced species (*i.e.,* wolves), Idaho cannot and will not, agree to the reintroduction of salmon or steelhead above Hells Canyon Dam.

Idaho remains committed to working collaboratively with the state of Oregon to ensure that Idaho Power's hydropower facilities within Hells Canyon comply with appropriate water quality standards. Please do not hesitate to contact my office with any questions or concerns.

As Always – Idaho, "Esto Perpetua"

C.L. "Butch" Otter
Governor of Idaho

[1] IDAHO CODE §§ 67-6302, 67-818; Idaho State Water Plan 2B (Nov. 2012).

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Addendum to Idaho Power Company's Section 401 Water-Quality Certification Application

Hells Canyon Complex, FERC Project No. 1971

July 2016

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1. INTRODUCTION

This addendum includes several recent additional information requests by the Oregon Department of Environmental Quality (ODEQ) and Idaho Power Company's (IPC) responses to those requests. Topics include consistency of units in the Snake River Stewardship Program (SRSP) proposal, coldwater refugia conditions, dissolved oxygen (DO) calculations, levels of toxics in the water column, operations, harmful algal blooms, and consistency of the SRSP and Riverside Operational Water-Quality Improvement (ROWQI) Project proposals with Oregon trading rules in Oregon Administrative Rules (OAR) chapter 340, division 039.

2. ODEQ REQUEST FOR ADDITIONAL INFORMATION ON JUNE 29, 2016

ODEQ Request

ODEQ staff continues to review the December 1, 2015, application for §401 certification for the Hells Canyon Complex (HCC). As noted in the June 7, 2016, call between Jim Tucker, IPC, and Eric Nigg, ODEQ, the ODEQ has determined the SRSP and the ROWQI Project fall under Oregon's water quality trading rules.

> The trading rules are contained in OAR 340-039-0001 through OAR 340-039-0043. Please provide documentation that describes how the SRSP and the ROWQI meet the requirements of a water quality trading plan, as described in OAR 340-039- 0025. The documentation may be submitted as an addendum to the December 1, 2015, application for §401 certification, which cross references the SRSP and the ROWQI with the trading plan requirements.
>
> Please provide the information by July 8, 2016. If IPC is unable to provide the materials by this date, please provide DEQ with the date IPC can complete the request.

IPC Response

On June 29 2016, the Oregon Department of Environmental Quality (ODEQ) submitted an additional information request to the Idaho Power Company (IPC) requesting that IPC submit additional information demonstrating whether and how the Snake River Stewardship Program (SRSP) and the Riverside Program are consistent with Oregon's water quality trading rules (OAR 340-039). In response to that request, IPC is submitting the following comparative tables.

While the Idaho Department of Environmental Quality (IDEQ) rule IDAPA 51.01.02.055.06 authorizes pollutant trading, and IDEQ is currently updating its trading guidelines, IDEQ has advised that the SRSP and Riverside Program will be treated as offsets under Idaho's rules and guidelines, and not as trades.

The tables below demonstrate that the SRSP and Riverside Program are fully consistent with the Oregon and Idaho water quality standards, the SR-HC TMDL, and any applicable Oregon or Idaho water quality trading and offset rules and guidelines. IPC is proposing the SRSP and Riverside Program for the purposes of the CWA section 401 certification for the licensing of the Hells Canyon Complex (HCC) by the Federal Energy Regulatory Commission (FERC) and has not characterized either program as a trade under Oregon or Idaho rules or guidelines. Nevertheless, ODEQ and IDEQ have advised IPC that classifying and analyzing the SRSP and Riverside Program as a trade or as an offset does not have material regulatory consequences to the SRSP or Riverside Program, nor will doing so result in the alteration of any of the compliance, monitoring or enforcement obligations associated with the 401 certification for the HCC FERC license.

The following comparative table includes all of the Oregon water quality trading rule provisions (left column), and an explanation of how the SRSP addresses those provisions, where applicable. In the right column, references have been made to the overall 401 application (IPC 401 Application), Section 7.1. and associated Exhibit 7.1-1 contained within the 401 application (SRSP), and the Snake River-Hells Canyon TMDL (SR-HC TMDL). Consistent with its stated purpose, the 2016 Oregon water quality trading Internal Management Directive (Trading IMD) has been used to supplement explanations where helpful.[1]

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
340-039-0001 **Purpose and Policy** (1) Purpose. This rule implements ORS 468B.555 to allow entities regulated under the Clean Water Act to meet pollution control requirements through water quality trading. This rule establishes the requirements for water quality trading in Oregon. (2) Policy. The Oregon Department of Environmental Quality may approve water quality trading only if it promotes one or more of the following Environmental Quality Commission policies: (a) Achieves pollutant reductions and progress towards meeting water quality standards; (b) Reduces the cost of implementing Total Maximum Daily Loads (TMDLs); (c) Establishes incentives for voluntary pollutant reductions from point and nonpoint sources within a watershed; (d) Offsets new or increased discharges resulting from growth; (e) Secures long-term improvement in water quality; or (f) Results in demonstrable benefits to water quality or designated uses the water quality standards are intended to protect.	• (1): The purpose statement in the trading rules aligns with intent of SRSP offset program [SRSP Ex. 7.1-1, § 2]. • (2): The SRSP promotes at least one of the listed EQC policies, and is therefore within DEQ's discretion to approve consistent with these rules. Specifically, the SRSP helps achieve thermal loading reduction above the Hells Canyon Complex (HCC), establishes incentives to engage other nonpoint sources in the program area, and helps to restore dynamic processes to reaches of the Snake River and its tributaries, including increased riparian shade, increasing water velocity (and potentially volume), decreasing temperature and aquatic macrophyte proliferation, and providing cold-water habitat for native species [SRSP Ex. 7.1-1, § 1].
340-039-0003 **Water Quality Trading Objectives** Water quality trading authorized under this rule must: (1) Be consistent with anti-degradation policies; (2) Not cause or contribute to an exceedance of water quality standards; (4) Be designed to result in a net reduction of pollutants from participating sources	• (1, 2, 4, 8): Oregon's antidegradation policy is found in OAR 340-041-0004. As stated in the Oregon trading IMD, Oregon's anti-degradation policy generally prohibits the lowering of existing water quality. Trading IMD, at 9. In the 2003 federal Trading Policy,

[1] "DEQ expects the majority of trading activity to be driven by the need to comply with NPDES permit requirements developed to implement a total maximum daily load (TMDL).This IMD is, therefore, primarily focused on water quality trades between nonpoint sources and NPDES permittees to comply with the latter's water quality-based effluent limitations. To the extent it is relevant and helpful, this IMD may also be used by DEQ staff to evaluate trading proposals that are part of the water quality certification of a federal permit or other approval issued under Clean Water Act (CW A) section 401 and Oregon Administrative Rules (OAR) chapter 340, division 048 (referred to throughout this IMD as a "401 WQC")." ODEQ, Trading IMD, at 6.

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
in the trading area; (8) Not create localized adverse impacts on water quality and existing and designated beneficial uses.	U.S. EPA states that it "does not believe that trades and trading programs will result in 'lower water quality' as that term is used in 40 CFR § 131.12(a)(2) ... when the trades or trading programs achieve a no net increase of the pollutant traded and do not result in any impairment of designated uses." Trading IMD, at 9. In line with EPA guidance, the Trading IMD instructs DEQ staff to ensure that trades are designed to result in a net reduction of pollutants in the trading area as required in OAR 340-039-0003(4), and that the proposed trade does not create localized adverse impacts on water quality and existing and designated beneficial uses as required in OAR 340-039-0003(8). Trading IMD, at 9. The HCC does not add heat to the system, but shifts heat impacts temporally [IPC 401 Application, § 6.1]. As such, the HCC will not cause or contribute to violations of water quality standards after implementation of the SRSP. By reducing thermal load through upstream watershed projects, the SRSP has been designed to achieve a net reduction in thermal loading in the program area. The SR-HC TMDL did not find that salmonid spawning below the Hells Canyon Dam (HCD) was impaired by temperature below the HCD [SR-HC TMDL, § 3.6.2]; these findings were reaffirmed in recent studies [IPC 401 Application, §§ 6.1.3, 7.1.1]. The SRSP was designed to avoid localized adverse impacts on water quality, aquatic species and habitat that could be caused by other technological options [IPC 401 Application, § 7.1.2.4.1.1].
(3) Be consistent with local, state, and federal water quality laws;	• (3): The SRSP has been designed to be consistent with all other laws [SRSP Ex. 7.1-1, § 2.5.2.1 (regulatory baseline); SRSP Ex. 7.1-1, Attachment 1 (document compatibility with local land use and cultural resource requirements, work permits obtained)].
(4) [*excerpted and addressed above with explanation for subsection (1)*]	
(5) Be designed to assist the state in attaining or maintaining water quality standards;	• (5): The SRSP has been designed to address the HCC's exceedance above the Oregon salmonid spawning temperature criterion, as defined in the SR-HC TMDL [IPC 401 Application, § 7.1.2.1].
(6) Be designed to assist in implementing TMDLs when applicable;	• (6): The SRSP is designed to help implement the SR-HC TMDL [IPC 401 Application, § 7.1.2.1; SRSP Ex. 7.1-1, § 1].
(7) Be based on transparent and practical Best Management Practices (BMPs) quality standards to ensure that water quality benefits and credits are generated as planned; and	• (7): The SRSP includes quality standards designed specifically for the proposed BMPs [SRSP Ex. 7.1-1, Attachment 1]. These standards ensure thermal benefits are created, monitored, and

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
(8) [*excerpted and addressed above with explanation for subsection (1)*]	tracked as part of the program.
340-039-0005 **Definitions** (1) Best Management Practices (BMPs): In-water or land-based conservation, enhancement or restoration actions that will reduce pollutant loading or create other water quality benefits. BMPs include, but are not limited to, structural and nonstructural controls and practices and flow augmentation. (2) BMP Quality Standards: Specifications for the design, implementation, maintenance and performance tracking of a particular BMP that ensure the estimated water quality benefits of a trading project are achieved, and that allow for verification that the BMP is performing as described in an approved trading plan. (3) Credit: A measured or estimated unit of trade for a specific pollutant that represents the water quality benefit a water quality trading project generates at a location over a specified period of time, above baseline requirements and after applying trade ratios or any other adjustments. (4) Public Conservation Funds: Public funds that are targeted to support voluntary natural resource protection or restoration. Examples of public conservation funds include United States Department of Agriculture (USDA) cost share programs, United States Environmental Protection Agency (EPA) section 319 grant funds, United States Fish and Wildlife Service Partners for Fish and Wildlife Program funds, State Wildlife Grants, and Oregon Watershed Enhancement Board restoration grants. Public funds that are not considered public conservation funds include: public loans intended to be used for water quality infrastructure projects, such as Clean Water State Revolving Funds, USDA Rural Development funds, and utility sewer storm water and surface water management fees. (5) Trading Area: A watershed or other hydrologically-connected geographic area, as defined within a water quality management plan adopted for a TMDL, trading framework or trading plan. A trading area must encompass the location of the discharge to be offset, or its downstream point of impact, if applicable, and the	• (1): The SRSP details two restoration action types—in-river channel adjustments, riparian revegetation—that will reduce pollutant loading and create additional water quality benefits [SRSP Ex. 7.1-1, § 2.2]. These actions are consistent with Oregon guidance on BMPs [Oregon Trading IMD, § 5(I)(F)(i)]. • (2): The SRSP includes specifications for design, implementation, maintenance and performance tracking for in-river and riparian revegetation BMPs [SRSP Ex. 7.1-1, Attachment 1]. • (3): In the SRSP, the equivalent to a credit is a "thermal benefit", which is a calculated estimate of the benefits that will accrue from an implemented restoration project once it fully matures. [SRSP Ex. 7.1-1, Definitions]. Thermal benefits are "aggregated" and must be sufficient to offset the "cumulative thermal load exceedance" (CTLE) at the outflow of the HCC. [SRSP Ex. 7.1-1, Definitions]. The CTLE accounts for the SR-HC TMDL margin of safety, and a reservoir attenuation factor, while thermal benefits from projects are also attenuated [IPC 401 Application, § 7.1.2.1]. • (4): In the SRSP, public conservation funds are similarly defined and restricted from use to develop thermal benefits [SRSP Ex. 7.1-1, § 2.5.2.2, FN 29]. • (5): In the SRSP, the trading area is defined as the "program area" [SRSP Ex. 7.1-1, § 2.1].

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
trading project to be implemented. (6) Trading Baseline: Pollutant load reductions, BMP requirements, or site conditions that must be met under regulatory requirements in place at the time of trading project initiation. (7) Trading Framework: A description contained in a TMDL water quality management plan, or water pollution control plan, adopted by rule or issued by order under ORS 468B.015 or 468B.110, that identifies trading elements applicable to one or more entities in a trading area. (8) Trading Plan: A plan that describes the design, implementation, maintenance, monitoring, verification and reporting elements of a water quality trade. (9) Trading Project: A site-specific implementation of a trading plan used to generate credits. (10) Trading Ratio: A numeric value used to adjust the number of credits generated from a trading project, or to adjust the number of credits that a credit user needs to obtain. (11) Verification: A process to confirm and document that a trading project is implemented and performing according to the approved trading plan and BMP quality standards, and to confirm the quantity of credits generated by the trading project. (12) Water Quality Benefit: The quantifiable water quality improvement or net pollutant reduction that can be reasonably attributed to BMPs at a trading project site. (13) Water Quality Trading or Trade: The use of water quality credits generated at one location in a trading area to comply with water quality-based requirements at another location within the trading area.	• (6): In the SRSP, trading baseline is defined as "regulatory baseline" [SRSP Ex. 7.1-1, § 2.5.2.1]. • (7): No such framework exists for the SRSP. • (8): The SRSP is analogous to the trading plan definition included in the rules [SRSP Ex. 7.1-1, Definitions]. • (9): The SRSP includes a similar definition of trading projects, also referred to as "sites." [SRSP Ex. 7.1-1, Definitions]. • (10): The 401 includes ratios that increase the number of benefits IPC needs to obtain [IPC 401 Application, § 7.1.2.1]. • (11): The SRSP includes a process to confirm implementation and performance consistent with BMP quality standards, and an ongoing project audit process [SRSP Ex. 7.1-1, § 2.6.3]. • (12): The SRSP defines "thermal benefits" similarly to and consistent with the rule [SRSP Ex. 7.1-1, Definitions]. • (13): The SRSP is designed to be consistent with the definition of trading found in the OARs.
340-039-0015 **Eligibility** (1) An entity regulated by a National Pollutant Discharge Elimination System (NPDES) permit or a federal permit or license for which DEQ has issued a water quality certification pursuant to Clean Water Act section 401 and OAR chapter 340, division 048 (a "401 water quality certification") is eligible to enter into a trade. (2) Water quality parameters eligible for water quality trading: (a) DEQ may authorize water quality trading for the following water quality parameters: temperature, ammonia, sediment, total suspended solids, and nutrients and other oxygen-demanding substances, including biochemical oxygen demand. (b) Water quality trading for pollutants that are toxic and either persist in the	• (1): As a licensee seeking a CWA section 401 certification from DEQ, IPC is eligible to enter into a trade. • (2a): The SRSP only addresses temperature [SRSP Ex. 7.1-1, § 1], which is an approved pollutant for trading under the rule. • (2b): The SRSPP does not propose any actions that implicate

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
environment or accumulate in the tissues of humans, fish, wildlife or plants is prohibited, except if trading is an element of a pollution reduction plan in a variance that has been issued by DEQ or the EQC and approved by EPA pursuant to OAR 340-041-0059. (c) Water quality trading authorized under this division may not be used to meet technology-based effluent limitations. (d) DEQ may authorize trading for other water quality parameters on a case-by-case basis provided it does not cause or contribute to an exceedance of a water quality standard. (3) Water bodies where trading may occur: (a) High quality waters. DEQ may authorize trading to maintain or improve water quality in water bodies that meet water quality standards, including but not limited to, trading projects designed to offset new or increased pollutant loads. (b) Water quality limited waters. DEQ may authorize trading where it is consistent with the water quality management plan in a TMDL or other water pollution control plan adopted by rule or issued by order under ORS 468B.015 or 468B.110, or in water bodies: (A) That are water quality limited but not subject to a TMDL; or (B) Where trading projects are designed to achieve progress towards meeting water quality standards before or while a TMDL is being developed. (4) BMPs eligible for credit generation must be quantifiable and have BMP quality standards.	pollutants described in Subsection (2)(b) of the rule. • (2c): This provision applies only to point sources and therefore does not apply to the HCC, a nonpoint source. • (2d): IPC is not seeking DEQ approval of any parameters that have not yet been approved in the rule. • (3): The SR-HC TMDL assigned a load allocation to the HCC to address exceedances of fall Chinook spawning criteria. The SR-HC TMDL water quality management plan (WQMP) includes trading among the implementation strategies that can be pursued [TMDL, § 6.1, Ch. 1]. • (4): The SRSP includes quality standards for the BMPs from which thermal benefits will be measured [SRSP Ex. 7.1-1, Attachment 1]. Thermal benefits from these projects will be quantified in kilocalories per day, using Shade-a-lator and wetland energy budgeting [SRSP Ex. 7.1-1, § 2.3].
340-039-0017 **Regulatory Mechanisms for Water Quality Trading** (1) NPDES Permitting: (a) Trading in Permits: DEQ may authorize water quality trading in an NPDES permit to meet water quality-based effluent requirements. (b) Compliance Schedules. Water quality trading may be included in an NPDES permit compliance schedule only if the trade is consistent with the requirements of OAR 340-041-0061 and any applicable regulations of the EPA. (c) Permit Variances. Water quality trading may be included as a component of the pollution reduction plan in a variance issued under OAR 340-041-0059. (2) 401 Water Quality Certifications. DEQ may condition a 401 water quality certification based on water quality trading consistent with this division.	• (1): The contents of this subsection are inapplicable because the SRSP is not related to NPDES permitting. • (2): ODEQ may condition a 401 certification upon consistency with

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
(3) Annual Reporting. The regulated entity must submit an annual report to DEQ that describes trading plan implementation and performance over the past year. The annual report must include information specific to each trading project implemented including: (a) The location of each trading project and BMPs implemented in the preceding year; (b) The trading project baseline; (c) The trading ratios used; (d) Trading project monitoring results; (e) Verification of trading plan performance including the quantity of credits acquired from each trading project, and the total quantity of credits generated under the trading plan to date; (f) A demonstration of compliance with OAR 340-039-0040(4), if applicable; and (g) Adaptive management measures implemented under the trading plan, if applicable.	the water quality trading rules. • (3): The SRSP provides for submission of annual monitoring reports to the DEQs [SRSP Ex. 7.1-1, § 2.6.2]. SRSP annual reports will describe the monitoring efforts and results generated from the year, and the volume of thermal benefits implemented during the year. In addition, annual monitoring reports for each implemented project, and the results of the performance confirmations and ongoing audits, will be made available. Moreover, at adaptive management intervals [see SRSP Ex. 7.1-1, § 3], IPC will provide progress reports documenting that programmatic assumptions related to thermal benefit estimates are consistent with observations to date. The SRSP will document the location and nature of all trading projects as part of ongoing tracking and reporting [SRSP Ex. 7.1-1, § 2.6.4]. The results of implementation and performance confirmations—which requires review of project documentation for consistency with quality standards, including baseline and ratio information—will be documented on the publicly accessible tracking and reporting website [SRSP Ex. 7.1-1, § 2.6.4; Attachment 1].
340-039-0020 **Trading Frameworks** (1) DEQ may establish one or more trading frameworks in a TMDL water quality management plan or water pollution control plan adopted by rule or issued by order under ORS 468B.015 or ORS 468B.110. If established, a trading framework must specify pollutants that are eligible for trading, the trading area, any priority areas, as well as regulations and applicable TMDL allocations and implementation schedules that will be used to derive trading baseline. (2) DEQ must provide an opportunity for public notice and comment before issuing a trading framework. (3) A trading framework is not required in order for DEQ to approve a water quality trading plan.	• (1): ODEQ has not established a trading framework for the Snake River-Hells Canyon TMDL. • (2): As no framework exists for this TMDL area, this provision does not apply. • (3): As noted in the rules, a trading framework is not required for DEQ to approve a trading plan.
340-039-0025 **Requirements of a Water Quality Trading Plan** (1) An eligible entity may not engage in water quality trading unless DEQ has reviewed and approved that entity's water quality trading plan. The use of credits will be authorized after all elements of a DEQ-approved trading plan required by subsection (5) of this rule are incorporated as enforceable conditions of an NPDES	• (1): As DEQ has determined the SRSP must be consistent with the water quality trading program, DEQ's approval of the SRSP as part of the 401 certification process constitutes approval of the trading plan.

Oregon Water Quality Trading Rule	Explanation of How SRSP Addresses Oregon WQT Provision
permit issued under OAR chapter 340 division 045 or a 401 water quality certification issued under OAR chapter 340 division 048.	
(2) For NPDES permittees trading may be proposed as part of a permittee's application for permit renewal or modification.	• (2): This subsection is inapplicable because the proposed SRSP is not part of an NPDES permit.
(3) DEQ must provide an opportunity for public notice and comment on a trading plan before approving the trading plan. DEQ may amend the trading plan or require amendments to the trading plan prior to approval. Individual trading projects must be consistent with an approved trading plan. Individual trading projects do not require separate public notice and comment.	• (3): DEQ will provide a public comment opportunity on the draft 401 certification [OAR 340-048-0027], which will include the SRSP.
(4) A trading plan must be consistent with an applicable DEQ-issued trading framework if such a framework exists at the time DEQ approves the trading plan.	• (4): This subsection is inapplicable because no framework.
(5) A trading plan must include all of the following elements and a description of how the elements were derived or calculated: (a) The parameter for which water quality trading is proposed;	• (5a): The SRSP is focused on thermal benefits, measured in kilocalories of thermal load [SRSP Ex. 7.1-1, § 2.3].
(b) Trading baseline: A trading plan must identify any applicable regulatory requirements from OAR 340-039-0030(1) that apply within the trading area and that must be implemented to achieve baseline requirements;	• (5b): The 401 application [§ 6.1] and SRSP discuss the regulatory baseline requirements in Idaho and Oregon that could apply [SRSP Ex. 7.1-1, § 2.5.2.1].
(c) Trading area: A description of the trading area including identification of the location of the discharge to be offset, its downstream point of impact, if applicable, where trading projects are expected to be implemented, and the relationship of the trading projects to beneficial uses in the trading area;	• (5c): IPC must address temperature load below the HCD [IPC 401 Application, § 7.1.1]. The SRSP includes a description of the program area in which projects may be located. The SRSP program area allows for projects: 1) located below Swan Falls Dam and upstream of HCD in the Snake River, and 2) located on hydrologically connected tributaries to the Snake River upstream of the HCD (including but not limited to): Boise River, Brownlee Reservoir creeks, Burnt River, Malheur River, Middle Snake-Payette River, Owyhee River, Payette River, Pine Creek, Powder River, Succor Creek, and Weiser River. Thermal benefit modeling of riparian areas in these tributaries does not extend upstream beyond any reservoir or substantial impoundment [SRSP Ex. 7.1-1, § 2.3]. The SRSP is designed to provide temperature and other ancillary water quality, and habitat benefits to the Snake River watershed [IPC 401 Application, § 7.1.2].
(d) BMPs: A description of the water quality benefits that will be generated, the BMPs that will be used to generate water quality benefits, and applicable BMP quality standards;	• (5d): The SRSP describes how "thermal benefits" will be generated [SRSP Ex. 7.1-1, § 2.3], the BMPs that will be used to generate thermal benefits [SRSP Ex. 7.1-1, § 2.2], and includes applicable BMP quality standards [SRSP Ex. 7.1-1, Attachment 1].

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(e) Trading ratios: A description of applicable trading ratios, the basis for each applicable trading ratio, including underlying assumptions for the ratio, and a statement indicating whether those ratios increase or decrease the size of a credit obligation or the number of credits generated from an individual trading project;	• (5e): The 401 Application describes how the following ratios were determined and how/where they apply: 10% margin of safety from SR-HC TMDL increases size of the cumulative thermal load exceedance (CTLE) offset need [§ 7.1.2.1]; 50% in-reservoir attenuation doubles the size of the CTLE offset need [§ 7.1.2.1.1]; in-river attenuation reduces value of thermal benefit projects by 22-25% [§ 7.1.2.1.2].
(f) Credits: A description of the credits needed to meet water quality-based requirements of an NPDES permit or 401 water quality certification, including: (A) Quantity and timing: The number of credits needed and any credit generation milestones, including a schedule for credit generation; (B) Methods used: How credits will be quantified, including the assumptions and inputs used to derive the number of credits; and (C) Duration of credits: A description of the length of time credits are expected to be used.	• (5f): The 401 Application calculates the "thermal load exceedance" needed to offset impacts to salmonid spawning, and describes how all daily exceedances during this critical period are summed into a "cumulative thermal load exceedance" (CTLE) that IPC must offset [IPC 401 Application, § 6.1.2.3.2]. The SRSP describes how the thermal benefit milestones were developed, including an assessment of thermal benefit supply compared against thermal benefit need, and recruitment feasibility [SRSP Ex. 7.1-1, §§ 2.4, 2.6.5]. The quantification methods used, including assumptions and details on inputs, are described [SRSP Ex. 7.1-1, § 2.3]. Thermal benefits from projects are used to offset the CTLE during the salmonid spawning period [IPC 401 Application, § 6.1.3.2]. Thermal benefits from a single restoration project may be counted in multiple years so long as the restoration action is still functioning that year in accord with performance confirmation audits [SRSP Ex. 7.1-1, § 2.5.3]. Thermal benefits become valid for use upon implementation confirmation [SRSP Ex. 7.1-1, § 2.6.3].
(g) Monitoring. The trading plan must include a description of the following: (A) Proposed methods and frequency of trading project BMP monitoring; and (B) Proposed methods and frequency of how water quality benefits generated by a trading project will be monitored;	• (5g): The SRSP includes a description of the three tiered monitoring method proposed for the SRSP, as well as a description of how frequently those monitoring activities will take place [SRSP Ex. 7.1-1, § 2.6.2].
(h) Trading Plan Performance Verification: A description of how the entity will verify and document for each trading project that BMPs are conforming to applicable quality standards and credits are generated as planned; and	• (5h): The SRSP relies on a hybrid "audit" verification procedure comprised of two key components: 1) third-party confirmation that every project has been implemented consistent with restoration quality standards and guidelines; and 2) annual randomized project site audits of a percentage of projects by independent third party reviewers to confirm that projects are being maintained, monitored and tracked consistent with restoration quality standards and guidelines such that they are likely to achieve the modeled thermal benefits at the program's

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(i) Tracking and Reporting: A description of how credit generation, acquisition and usage will be tracked and how this information will be made available to the public.	conclusion [SRSP Ex. 7.1-1, § 2.6.3]. • (5i): SRSP progress will be tracked via a publicly accessible tracking and reporting website [SRSP Ex. 7.1-1, § 2.6.4]. This website serves as a registry (i.e., ledger) for tracking thermal benefit totals as they accrue, and will host project design and monitoring information (including photo points), and the results of implementation and performance confirmations.
(6) Adaptive Management: Trading plans must include a description of how monitoring and other information may be used over time to adjust trading projects and under what circumstances;	• (6): The SRSP acknowledges the multi-decadal timeframe of the anticipated 401 certification and FERC license. The SRSP therefore incorporates the ability to adapt implementation, maintenance, monitoring, and performance tracking practices to reflect new knowledge and information as it emerges [SRSP Ex. 7.1-1, § 3].
(7) Trading Plan Revision: An approved trading plan must be revised during permit or 401 water quality certification renewal or if there is a change in circumstances that affects a trading plan element required by subsection (5) of this rule. Revised trading plans must be submitted to DEQ for review and approval and must be given an opportunity for public notice and comment. DEQ will reopen and modify the permit or 401 water quality certification for any revisions affecting an enforceable condition.	• (7): the SRSP will undergo adaptive management review by the DEQs on a five-year cycle [SRSP Ex. 7.1-1, § 3.1]. A five-year review cycle provides a regular opportunity to review available data from the previous years of implementation, maintenance, and monitoring, and to incorporate new technologies and lessons learned through previous implementation cycles into restoration quality standards and guidelines, as well as monitoring, maintenance, and performance tracking protocols. Periodic agency review of implementation and performance progress will also allow for course correction with respect to implementation milestones and obligations, and for updates to the regulatory baseline determinations associated with the SRSP, should any of these updates be needed.
340-039-0030 **Requirements for Trading Baselines** (1) Trading baseline must account for the following regulatory requirements applicable to the trading project at the time of trading project initiation:	• (1): “Because baseline is determined at the time of project initiation, much of the information necessary to determine site-specific baseline information will likely be unknown at the time of trading plan review and approval.” Trading IMD, § 5(II)(C). The current regulatory baseline assessment included in the SRSP will be updated on a five-year basis that aligns with the SRSP adaptive management cycle [SRSP Ex. 7.1-1, § 3.1]. The results of this periodic assessment will constitute the regulatory baseline requirements associated with project sites implemented in the SRSP program area during the subsequent five-year period. For the

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	purposes of determining the extent of thermal benefits credited towards compliance with the cumulative thermal load exceedance, once a SRSP project site has been implemented, the regulatory baseline analysis associated with that project site will remain in effect for as long as the project site continues to be supported and maintained in a manner consistent with the SRSP.
(a) NPDES permit requirements;	• (1a): If IPC obtains thermal benefits from a NPDES permit holder in the SRSP program area, it will ensure that the actions generating those benefits are not already required by that NPDES permit.
(b) Rules the Oregon Department of Agriculture issued for an agricultural water quality management area under OAR chapter 603 division 095;	• (1b): The SRSP program area overlaps with four Oregon agricultural management plan (AgWQMP) areas: Owyhee (OAR 603-095-2700), Malheur (OAR 603-095-0900), Burnt (OAR 603-095-3200), and Powder/Brownlee (OAR 603-095-3600). While these potentially applicable AgWQMP area rules protect against activities that will degrade riparian vegetation at potential SRSP riparian project sites, they do not establish any affirmative restoration obligations on those project sites. Rather, these passive, non-disturbance regulations only require that land be left alone so that vegetation can be established.
(c) Rules the Oregon Board of Forestry issues under OAR chapter 629 divisions 610-680;	• (1c): The SRSP did not identify any areas where currently applicable BOF rules would overlap with SRSP program area potential sites [SRSP Ex. 7.1-1, § 2.5.2.1]. In some instances, no baseline obligations exist: "If no regulatory requirements described in OAR 340-039-0030(1) exist or apply within the trading area, the trading plan may state that baseline is 'existing conditions.'" Trading IMD, § 5(II)(C).
(d) Requirements of a federal land management plan, or an agreement between a federal agency and the state;	• (1d): The SRSP notes that demonstrating additionality on publicly owned land involves the consideration of management actions, if any, which are already required by the federal or state management statute and plans governing that parcel. If any of those statutes or management plans already require active restoration of the riparian area where SRSP project sites would be implemented, it would be necessary to discount the thermal benefits generated from that project site so as to ensure that those benefits are not "double-counted." [SRSP Ex. 7.1-1, § 2.5.2.1]. If projects are planned on lands covered by such plans, any requirements stemming from those plans would be applied.

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(e) Requirements established in a Clean Water Act Section 401 water quality certification;	• (1e): The IMD notes that if a 401 license holder would like to generate credits, it would need to complete actions beyond the general and mitigation conditions included in its 401 application [Trading IMD, § 5(I)(H)(iii)]. However, IPC's proposed temperature mitigation in its 401 application is to generate thermal benefits, so the baseline considerations that apply are those related to other nonpoint source generators of thermal benefits [Trading IMD, § § 5(I)(H)(iv)].
(f) Local ordinances;	• (1f): Depending on a property's location within the SRSP program area, it may be subject to county or city comprehensive plan, zoning ordinances, subdivision ordinances or other local code requirements. Baseline requirements at the county and city level may therefore vary depending on location, land use type, applicable overlay districts (if any) and the type of BMP employed to generate thermal benefits. No county and city regulations in the SRSP program currently affirmatively require riparian restoration work. Site-specific local requirements will be documented as part of project eligibility [SRSP Ex. 7.1-1, Attachment 1].
(g) Tribal laws, rules, or permits; (h) Other applicable rules affecting nonpoint source requirements;	• (1g, h): In some instances, no baseline obligations exist: "If no regulatory requirements described in OAR 340-039-0030(1) exist or apply within the trading area, the trading plan may state that baseline is 'existing conditions.'" Trading IMD, § 5(II)(C). The SRSP did not identify any tribal laws, rules or permits, or other currently applicable rules affecting nonpoint source requirements [SRSP Ex. 7.1-1, § 2.5.2.1].
(i) Projects completed as part of compensatory mitigation, or projects required under a permit or approval issued under Clean Water Act section 404, or a supplemental environmental project used to settle a civil penalty imposed under OAR chapter 340 division 012 or the Clean Water Act; and	• (1i): As part of SRSP project eligibility screening and documentation, IPC will ensure that such projects are not used to generate thermal benefits for the purposes of 401 compliance [SRSP Ex. 7.1-1, § 2.5.1, Attachment 1].
(j) Regulatory requirements a designated management agency establishes to comply with a DEQ-issued TMDL, water quality management plan or another water pollution control plan adopted by rule or issued by order under ORS 468B.015 or 468B.110.	• (1j): Pursuant to the SR-HC TMDL WQMP, affirmative obligations to restore instream or riparian areas would be derived from implementation plans issued by designated management agencies (DMAs). Relevant DMAs identified in the DEQ SR-HC TMDL WQMP include IPC, ODA, ODEQ, ODOF [SR-HC TMDL, § 6.1, Ch. 5]. The SR-HC TMDL "implementation plans" created by these DMAs incorporate and rely on existing regulatory mechanisms (e.g.,

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(2) BMPs required to meet baseline requirements and BMPs used to generate additional water quality benefits and trade credits may be installed simultaneously.	AgWQMP area rules), but do not create stand-alone obligations to restore riparian or in-river areas. • (2): The SRSP does not explicitly address this issue, but will do so if applicable baseline requirements must be implemented at sites.
340-039-0035 **Requirements for Trading Areas** (1) DEQ may establish trading areas in trading frameworks. (2) All trading areas must be consistent with any applicable TMDL water quality management plan, independent state water quality management plans, or trading framework.	• (1): inapplicable because no trading framework. • (2): The SRSP establishes a program area [SRSP Ex. 7.1-1, § 2.3] that is consistent with Oregon's SR-HC TMDL water quality management plan (WQMP) [TMDL, § 6.1, Ch. 3]. The Oregon WQMP notes that one primary factor driving temperature impacts in the "geographic region of interest" is "riparian vegetation disturbance in upstream reaches and tributaries."
340-039-0040 **Requirements for Credits** (1) Credits used for compliance with NPDES permit and 401 water quality certification requirements must be generated within the trading area of an approved trading plan. (2) A credit may not be used to meet a regulatory obligation by more than one entity at any given time. (3) Credits may be generated only from BMPs that result in water quality benefits above trading baseline requirements. (4) Credits generated under an approved trading plan may not include water quality benefits obtained with public conservation funds. Where public sources of funding are used for credit-generating activities, it is the entity's responsibility to demonstrate compliance with this requirement in its annual report. (5) Credits may be used for compliance with NPDES permit requirements and 401 water quality certifications once implementation of BMPs has been verified as consistent with applicable BMP quality standards according to OAR 340-039-0025(5)(h). (6) Credits may be generated from BMPs installed before DEQ approves a trading plan if BMPs are verified as having been implemented consistent with BMP quality standards identified in a subsequently approved trading plan and are functioning effectively.	• (1): Only thermal benefits generated within the SRSP trading area will be eligible for use in the 401 [SRSP Ex. 7.1-1, Attachment 1, quality standard section on eligibility]. • (2): SRSP thermal benefits will only be used by IPC, and will be tracked accordingly [SRSP Ex. 7.1-1, § 2.5.2 (financial additionality); § 2.6.4 (tracking)]. • (3): The SRSP describes how regulatory baseline applies to the thermal benefit generating actions in the program area [SRSP Ex. 7.1-1, § 2.5.2.1]. • (4): SRSP thermal benefits will not be funded via public conservation funds [SRSP Ex. 7.1-1, § 2.5.2]. • (5): Before thermal benefits can be used by IPC toward its 401 obligation, they will be confirmed as having been implemented consistent with the BMP quality standards attached to the SRSP [SRSP Ex. 7.1-1, § 2.5.4]. • (6): If IPC implements thermal benefit producing projects prior to DEQ approval of the 401, those projects will be implemented consistent with SRSP quality standards and will need to be verified prior to being used for 401 compliance.

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340-039-0043 **Requirements for Trading Ratios** (1) Water quality trades must include one or more trading ratios that apply to credits. Ratio components and underlying assumptions must be clearly documented in the trading plan. (2) Trading ratios may be used to account for variables associated with a trading project including the following: (a) Attenuation of a water quality benefit between the location where credit-generating BMPs occur and the point of use; (b) Pollutant equivalency; (c) Uncertainty of BMP performance or water quality benefit measurement or estimate; (d) Types of risk not associated with BMP performance; (e) Time lag after BMP installation before a BMP produces full water quality benefit; (f) Credit for trading projects located in priority areas; or (g) Credit retirement to ensure a net reduction in water pollution.	• (1): The 401 includes three ratio components, which affect the size of the offset obligation, and the value of thermal benefits from projects. The assumptions underlying these ratios are described in the 401 application [§ 7.1.2.1]. • (2a): The 401 Application discounts the value of thermal benefits by 22% (instream projects) and 25% (riparian shade projects), respectively, to account for in-river attenuation of benefits between project sites and the in-flow into the HCC [§ 7.1.2.1.2]. The 401 Application doubles the size of the CTLE offset need to account for the 50% in-reservoir attenuation of thermal benefits as they travel the HCC reservoirs [§ 7.1.2.1.1]. • (2b): Pollutant equivalency is not applicable since all actions measured are in kcals/day, thereby making a ratio unnecessary. • (2c, d): The 401 Application increases the size of the cumulative thermal load exceedance by 10% to account for the SR-HC TMDL margin of safety factor [§ 7.1.2.1]. This factor is meant to cover uncertainty in the load calculation. • (2e): N/A. Anticipated compliance required at end of FERC license term (approximately year 50), which aligns with the multi-decade timeframe that may be necessary to implement the SR-HC TMDL [§ 6.1, Ch. 1]. Unlike the shorter NPDES horizon—where there is a time lag ratio in place to align the 5-year permit term with a 20-year growth period—full tree growth will be achieved before the license expires. Instream projects, which may constitute a significant portion of the SRSP, will yield full benefits immediately. • (2f): N/A. While SRSP projects are designed to generate additional habitat benefits in priority areas, IPC does not seek a ratio for implementing these projects. • (2g): N/A. SRSP projects will produce thermal benefits all year long. However, IPC will only be claiming aggregate thermal benefits during the July – October period of the year.

The following comparative table includes all of the Oregon water quality trading rule provisions (left column), and an explanation of how the Riverside Operational Water-Quality Improvement Project (ROWQIP) addresses those provisions, where applicable. In the right column, references have been made to the overall 401 application (IPC 401 Application), section 7.2.1 and associated Exhibits 7.2-1 and 7.2-2 contained within the 401 application (ROWQIP), and the Snake River-Hells Canyon TMDL (SR-HC TMDL). Consistent with its stated purpose, the 2016 Oregon water quality trading Internal Management Directive (Trading IMD) has been used to supplement explanations where helpful.[1]

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340-039-0001 **Purpose and Policy** (1) Purpose. This rule implements ORS 468B.555 to allow entities regulated under the Clean Water Act to meet pollution control requirements through water quality trading. This rule establishes the requirements for water quality trading in Oregon. (2) Policy. The Oregon Department of Environmental Quality may approve water quality trading only if it promotes one or more of the following Environmental Quality Commission policies: (a) Achieves pollutant reductions and progress towards meeting water quality standards; (b) Reduces the cost of implementing Total Maximum Daily Loads (TMDLs); (c) Establishes incentives for voluntary pollutant reductions from point and nonpoint sources within a watershed; (d) Offsets new or increased discharges resulting from growth; (e) Secures long-term improvement in water quality; or (f) Results in demonstrable benefits to water quality or designated uses the water quality standards are intended to protect.	• (1): The purpose statement in the trading rules aligns with intent of Riverside Operational Water-Quality Improvement Project (ROWQIP) [IPC 401 Application, § 7.2, page 196]. • (2): The ROWQIP promotes at least one of the listed EQC policies, and is therefore with DEQ's discretion to approve consistent with these rules. Specifically, the ROWQIP helps achieve phosphorus loading reduction above the Hells Canyon Complex (HCC), to meet corresponding required loads in Brownlee Reservoir to meet the DO load allocation required in the SR-HC TMDL [IPC 401 Application, § 7.2.1.1.1. pg 198]. It also establishes incentives for voluntary pollutant reductions by the Riverside Irrigation District.
340-039-0003 **Water Quality Trading Objectives** Water quality trading authorized under this rule must: (1) Be consistent with anti-degradation policies; (2) Not cause or contribute to an exceedance of water quality standards; (4) Be designed to result in a net reduction of pollutants from participating sources	• (1, 2, 4, and 8): Oregon's antidegradation policy is found in OAR 340-041-0004. As stated in the Oregon trading IMD, Oregon's anti-degradation policy generally prohibits the lowering of existing

[1] "DEQ expects the majority of trading activity to be driven by the need to comply with NPDES permit requirements developed to implement a total maximum daily load (TMDL).This IMD is, therefore, primarily focused on water quality trades between nonpoint sources and NPDES permittees to comply with the latter's water quality-based effluent limitations. To the extent it is relevant and helpful, this IMD may also be used by DEQ staff to evaluate trading proposals that are part of the water quality certification of a federal permit or other approval issued under Clean Water Act (CW A) section 401 and Oregon Administrative Rules (OAR) chapter 340, division 048 (referred to throughout this IMD as a "401 WQC")." ODEQ, Trading IMD, at 6.

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in the trading area; (8) Not create localized adverse impacts on water quality and existing and designated beneficial uses.	water quality. Trading IMD, at 9. In the 2003 federal Trading Policy, U.S. EPA states that it "does not believe that trades and trading programs will result in 'lower water quality' as that term is used in 40 CFR § 131.12(a)(2) ... when the trades or trading programs achieve a no net increase of the pollutant traded and do not result in any impairment of designated uses." Trading IMD, at 9. In line with EPA guidance, the Trading IMD instructs DEQ staff to ensure that trades are designed to result in a net reduction of pollutants in the trading area as required in OAR 340-039-0003(4), and that the proposed ROWQIP project does not create localized adverse impacts on water quality and existing and designated beneficial uses as required in OAR 340-039-0003(8). Trading IMD, at 9. The 401 Application has been designed to avoid localized DO impacts at the ROWQIP project location. The ROWQIP is designed to improve downstream water quality, and therefore conditions for beneficial uses, in waters that previously received highly degraded water. By minimizing the canal spill of water that is severely degraded, water quality conditions for beneficial uses in downstream waters—which were historically receiving this highly degraded water—should be improved. Prior to implementation, downstream water bodies received larger loading of pollutants and generally water of poor quality.
(3) Be consistent with local, state, and federal water quality laws; (4) [*excerpted and addressed above with explanation for subsection (1)*]	• (3): The ROWQIP has been designed by IPC, in cooperation with Riverside Irrigation District, to be consistent with all existing local, state, and federal water quality laws.
(5) Be designed to assist the state in attaining or maintaining water quality standards; (6) Be designed to assist in implementing TMDLs when applicable;	• (5,6): The ROWQIP has been designed to address IPC's DO allocation as defined in the SR-HC TMDL [IPC 401 Application, § 7.2; SR-HC TMDL, § 4.0.2.8]. IPC is proposing the ROWQIP to implement the DO load allocation assigned to IPC in the SR-HC TMDL. The RIDOWQIP is expected to fully address the 1,125 ton per year DO load allocation assigned to Brownlee Reservoir in the SR-HC TMDL.
(7) Be based on transparent and practical Best Management Practices (BMPs) quality standards to ensure that water quality benefits and credits are generated as planned; and	• (7): The ROWQIP is designed to be "consistent with generally accepted quality standards and guidelines for canal operations,"

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(8) [*excerpted and addressed above with explanation for subsection (1)*]	the detail provided on ROWQIP design and operations should provide a sufficient substitute for general quality standards which are designed to inform the implementation of multiple projects [IPC 401 Application, § 7.2.1.1.1; Canal Operating Guidelines Ex. 7.2-2, § 1].
340-039-0005 **Definitions** (1) Best Management Practices (BMPs): In-water or land-based conservation, enhancement or restoration actions that will reduce pollutant loading or create other water quality benefits. BMPs include, but are not limited to, structural and nonstructural controls and practices and flow augmentation. (2) BMP Quality Standards: Specifications for the design, implementation, maintenance and performance tracking of a particular BMP that ensure the estimated water quality benefits of a trading project are achieved, and that allow for verification that the BMP is performing as described in an approved trading plan. (3) Credit: A measured or estimated unit of trade for a specific pollutant that represents the water quality benefit a water quality trading project generates at a location over a specified period of time, above baseline requirements and after applying trade ratios or any other adjustments. (4) Public Conservation Funds: Public funds that are targeted to support voluntary natural resource protection or restoration. Examples of public conservation funds include United States Department of Agriculture (USDA) cost share programs, United States Environmental Protection Agency (EPA) section 319 grant funds, United States Fish and Wildlife Service Partners for Fish and Wildlife Program funds, State Wildlife Grants, and Oregon Watershed Enhancement Board restoration grants. Public funds that are not considered public conservation funds include: public loans intended to be used for water quality infrastructure projects, such as Clean Water State Revolving Funds, USDA Rural Development funds, and utility sewer storm water and surface water management fees.	• (1): The ROWQIP is an in-water action that involves the automated operation of the irrigation canal delivery system in order to reduce phosphorus loading the Boise and Snake rivers. Automation minimizes the withdrawal of higher quality water and maximizes the reuse of lower quality water. • (2): The ROWQIP proposal includes specifications for project designs, implementation actions, maintenance actions, monitoring, and performance tracking [IP 401 Application, Exhibit 7.2-2: Riverside Operational Water-Quality Improvement Project (ROWQIP)]. • (3): In the ROWQIP, the equivalent to a credit is a phosphorus “load reduction”, in units of pounds per day, which will be estimated based on changes in canal operations [IPC 401 Application, § 7.2.1.1.3]. Reductions will be calculated annually from measured data and will continue to be evaluated based on monitoring as outlined in the proposal. Based on the results presented in the application, it is reasonable to assume that continued operation of the ROWQIP should meet DO obligations outlined in SR-HC TMDL [IPC 401 Application, § 7.2.1.1.2]. • (4): In the ROWQIP, IPC clearly states its intention to contract directly with Riverside Irrigation District. While not stated explicitly in the 401 Application, IPC will not use public conservation funds to support the ROWQIP [IPC 401 Application, § 7.2.1.1.8].

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(5) Trading Area: A watershed or other hydrologically-connected geographic area, as defined within a water quality management plan adopted for a TMDL, trading framework or trading plan. A trading area must encompass the location of the discharge to be offset, or its downstream point of impact, if applicable, and the trading project to be implemented.	• (5): While not stated explicitly in the 401 Application, the trading area for the ROWQIP is the "district boundary" for Riverside Canal [IPC 401 Application, § 7.2.1.1.1; page 197].
(6) Trading Baseline: Pollutant load reductions, BMP requirements, or site conditions that must be met under regulatory requirements in place at the time of trading project initiation.	• (6): The 401 Application does not explicitly address the regulatory baseline requirements in Idaho and Oregon that could apply to the ROWQIP. However, there are no current regulatory requirements that Riverside Irrigation District change its canal operations or reduce phosphorus loads.
(7) Trading Framework: A description contained in a TMDL water quality management plan, or water pollution control plan, adopted by rule or issued by order under ORS 468B.015 or 468B.110, that identifies trading elements applicable to one or more entities in a trading area.	• 7): No such framework exists for the ROWQIP.
(8) Trading Plan: A plan that describes the design, implementation, maintenance, monitoring, verification and reporting elements of a water quality trade.	• (8): The 401 Application description of the ROWQIP and its associated appendices include and address the elements of a trading plan definition included in the rules [IPC 401 Application, § 7.2, ROWQIP Exhibits 7.2-1 and 7.2-2].
(9) Trading Project: A site-specific implementation of a trading plan used to generate credits.	• (9): The ROWQIP is the equivalent of a trading project designed to address the DO load allocation assigned to IPC in the SR-HC TMDL [IPC 401 Application, § 7.2.1.1].
(10) Trading Ratio: A numeric value used to adjust the number of credits generated from a trading project, or to adjust the number of credits that a credit user needs to obtain.	• (10): While trading ratios are not specifically referenced in the ROWQIP, the concept is addressed through the Equivalent Phosphorus Load calculations for ROWQIP [IPC 401 Application, § 7.2.1.1.2], and the difference between the project benefit and compliance need [IPC 401 Application, §§ 7.2.1.1.2 (15,000 lbs phosphorus needed; Ex. 7.2-2 – Appendix 2; § 7.2.1.1.4.2 (31,920 lbs produced from project in 2014)]. Based on the information provided in the application exhibit document describing the movement and cycling of phosphorus within the Snake River and Brownlee Reservoir, no attenuation ratio is necessary [IPC 401 Application, 7.2-2 Exhibit].
(11) Verification: A process to confirm and document that a trading project is implemented and performing according to the approved trading plan and BMP quality standards, and to confirm the quantity of credits generated by the trading project.	• (11): The ROWQIP will include a process for third-party verification "if required" by HCC CWA §401 certification requirements [IPC 401 Application, § 7.2.1.1.5; Monitoring and Reporting].
(12) Water Quality Benefit: The quantifiable water quality improvement or net	

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pollutant reduction that can be reasonably attributed to BMPs at a trading project site. (13) Water Quality Trading or Trade: The use of water quality credits generated at one location in a trading area to comply with water quality-based requirements at another location within the trading area.	• (12): The ROWQIP defines "phosphorus reductions" similarly to and consistent with the definition of water quality benefits in the rule [IPC 401 Application, § 7.2.1.1.3, see Equation 2]. • (13): The ROWQIP is consistent with the definition of trading found in the OARs. The ROWQIP is also consistent with the potential implementation strategy specifically identified in the SR-HC TMDL, which specifically identifies upstream phosphorus reductions as a viable option for addressing the DO load allocation in Brownlee Reservoir [SR-HC TMDL, §4.0.2.8].
340-039-0015 **Eligibility** (1) An entity regulated by a National Pollutant Discharge Elimination System (NPDES) permit or a federal permit or license for which DEQ has issued a water quality certification pursuant to Clean Water Act section 401 and OAR chapter 340, division 048 (a "401 water quality certification") is eligible to enter into a trade. (2) Water quality parameters eligible for water quality trading: (a) DEQ may authorize water quality trading for the following water quality parameters: temperature, ammonia, sediment, total suspended solids, and nutrients and other oxygen-demanding substances, including biochemical oxygen demand. (b) Water quality trading for pollutants that are toxic and either persist in the environment or accumulate in the tissues of humans, fish, wildlife or plants is prohibited, except if trading is an element of a pollution reduction plan in a variance that has been issued by DEQ or the EQC and approved by EPA pursuant to OAR 340-041-0059. (c) Water quality trading authorized under this division may not be used to meet technology-based effluent limitations. (d) DEQ may authorize trading for other water quality parameters on a case-by-case basis provided it does not cause or contribute to an exceedance of a water quality standard. (3) Water bodies where trading may occur: (a) High quality waters. DEQ may authorize trading to maintain or improve water quality in water bodies that meet water quality standards, including but not limited to, trading projects designed to offset new or increased pollutant loads. (b) Water quality limited waters. DEQ may authorize trading where it is consistent with the water quality management plan in a TMDL or other water pollution control plan adopted by rule or issued by order under ORS 468B.015 or 468B.110,	• (1): As a licensee seeking a CWA section 401 certification from DEQ, IPC is eligible to enter into a trade. • (2a): The ROWQIP only addresses phosphorus [IPC 401 Application, § 7.2], which is an approved pollutant for trading under the rule. • (2b): The ROWQIP does not propose any actions that implicate pollutants described in Subsection (2)(b) of the rule. • (2c): This provision applies only to point sources and therefore does not apply to the HCC, a nonpoint source. • (2d): IPC is not seeking DEQ approval of any parameters that have not yet been approved in the rule. • (3): The SR-HC TMDL—which was established to address, among other things, dissolved oxygen impairment in Brownlee Reservoir from July 1-September 7—assigned a load allocation to IPC. The SR-HC TMDL water quality management plan (WQMP) from the state of Oregon [TMDL, § 6.1] describes the strategies that will be used to implement the SR-HC TMDL. Pursuant to WQMP,

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or in water bodies: (A) That are water quality limited but not subject to a TMDL; or (B) Where trading projects are designed to achieve progress towards meeting water quality standards before or while a TMDL is being developed. (4) BMPs eligible for credit generation must be quantifiable and have BMP quality standards.	designated management agencies (DMAs) then submit "implementation plans" (IPs) outlining their respective implementation strategies. In the WQMP, trading is noted as one strategy that can be pursued [TMDL, § 6.1, Ch. 1]. IPC is identified as a DMA, and is instructed to "comply with conditions of Section 401 WQ Certification." [TMDL, § 6.1, Ch. 5]. • (4): The ROWQIP includes a complete description of project design and implementation which serve as quality standards for the BMP from which phosphorus reductions will be measured [Ex. 7.2-2, Appendix 3]. Sediment reductions from these projects will be quantified in pounds of phosphorus per day, using a mass balance approach and measured data [IPC 401 Application, § 7.2.1.1.3].
340-039-0017 **Regulatory Mechanisms for Water Quality Trading** (1) NPDES Permitting: (a) Trading in Permits: DEQ may authorize water quality trading in an NPDES permit to meet water quality-based effluent requirements. (b) Compliance Schedules. Water quality trading may be included in an NPDES permit compliance schedule only if the trade is consistent with the requirements of OAR 340-041-0061 and any applicable regulations of the EPA. (c) Permit Variances. Water quality trading may be included as a component of the pollution reduction plan in a variance issued under OAR 340-041-0059. (2) 401 Water Quality Certifications. DEQ may condition a 401 water quality certification based on water quality trading consistent with this division. (3) Annual Reporting. The regulated entity must submit an annual report to DEQ that describes trading plan implementation and performance over the past year. The annual report must include information specific to each trading project implemented including: (a) The location of each trading project and BMPs implemented in the preceding year; (b) The trading project baseline; (c) The trading ratios used; (d) Trading project monitoring results; (e) Verification of trading plan performance including the quantity of credits acquired from each trading project, and the total quantity of credits generated under the trading plan to date;	• (1): The contents of this subsection are inapplicable because the ROWQIP is not related to NPDES permitting. • (2): ODEQ may condition a 401 certification upon consistency with the water quality trading rules. • (3a-f): The ROWQIP requires submission of annual monitoring reports to the DEQs [IPC 401 Application, § 7.2.1.1.5]. ROWQIP annual reports will be "consistent with regional and national trading programs" and of "sufficient quality to support ODEQ and IDEQ determination of compliance" [IPC 401 Application, § 7.2.1.1.5]. In order to meet Oregon Water Quality Trading Rule requirements, the elements required for Annual Reporting will be included in Annual ROWQIP reports.

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(f) A demonstration of compliance with OAR 340-039-0040(4), if applicable; and (g) Adaptive management measures implemented under the trading plan, if applicable.	• (3g): Adaptive management is a component of the ROWQIP [IPC 401 Application, § 7.2.1.1.7]. Specific elements of the monitoring plan, monitoring approach, and procedures are described in *Riverside Canal Water Quality Project Monitoring Status Report for 2011, 2012, and 2013* [IPC 401 Application, Exhibit 7.2-2] and *Riverside Operational Water-Quality Improvement Project (ROWQIP), 2014 annual report* [IPC 401 Application, Exhibit 7.2-1].
340-039-0020 **Trading Frameworks** (1) DEQ may establish one or more trading frameworks in a TMDL water quality management plan or water pollution control plan adopted by rule or issued by order under ORS 468B.015 or ORS 468B.110. If established, a trading framework must specify pollutants that are eligible for trading, the trading area, any priority areas, as well as regulations and applicable TMDL allocations and implementation schedules that will be used to derive trading baseline. (2) DEQ must provide an opportunity for public notice and comment before issuing a trading framework. (3) A trading framework is not required in order for DEQ to approve a water quality trading plan.	• (1): ODEQ has not established a trading framework for the Snake River-Hells Canyon TMDL. • (2): As no trading framework exists for this TMDL area, this provision does not apply. • (3): As noted in the rules, a trading framework is not required for DEQ to approve a trading plan.
340-039-0025 **Requirements of a Water Quality Trading Plan** (1) An eligible entity may not engage in water quality trading unless DEQ has reviewed and approved that entity's water quality trading plan. The use of credits will be authorized after all elements of a DEQ-approved trading plan required by subsection (5) of this rule are incorporated as enforceable conditions of an NPDES permit issued under OAR chapter 340 division 045 or a 401 water quality certification issued under OAR chapter 340 division 048. (2) For NPDES permittees trading may be proposed as part of a permittee's application for permit renewal or modification. (3) DEQ must provide an opportunity for public notice and comment on a trading plan before approving the trading plan. DEQ may amend the trading plan or require amendments to the trading plan prior to approval. Individual trading projects must be consistent with an approved trading plan. Individual trading projects do not require separate public notice and comment. (4) A trading plan must be consistent with an applicable DEQ-issued trading	• (1): ODEQ will review the proposed ROWQIP as part of the 401 certification process. Although the ROWQIP is not proposed as a trading program, it is fully consistent with the Oregon water quality trading rules. The NPDES permit specific language is inapplicable. • (2): This subsection is inapplicable because no NPDES permit. • (3): DEQ will provide a public comment opportunity on the draft 401 certification [OAR 340-048-0027], which will include reference to the ROWQIP. • (4): This subsection is inapplicable because no trading framework.

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framework if such a framework exists at the time DEQ approves the trading plan. (5) A trading plan must include all of the following elements and a description of how the elements were derived or calculated:	
(a) The parameter for which water quality trading is proposed;	• (5a): The ROWQIP is focused on phosphorus reductions, measured in pounds of phosphorus per day [IPC 401 Application, § 7.2].
(b) Trading baseline: A trading plan must identify any applicable regulatory requirements from OAR 340-039-0030(1) that apply within the trading area and that must be implemented to achieve baseline requirements;	• (5b): The 401 Application does not explicitly address the regulatory baseline requirements in Idaho and Oregon that could apply to the ROWQIP. However, there are no current regulatory requirements that Riverside Irrigation District change its canal operations or reduce phosphorus loads. The ROWQIP description focuses on the legal requirements of a water right and associated contractual agreements [IPC 401 Application, § 7.2.1.1.3.2].
(c) Trading area: A description of the trading area including identification of the location of the discharge to be offset, its downstream point of impact, if applicable, where trading projects are expected to be implemented, and the relationship of the trading projects to beneficial uses in the trading area;	• (5c): The ROWQIP is intended to address dissolved oxygen conditions in Brownlee Reservoir [IPC 401 Application, § 7.1.1]. The ROWQIP will be implemented in the Riverside Irrigation District and will redirect irrigation return flows to be re-used on agricultural fields instead of directly returning them to the Snake and Boise rivers. The Project Description includes a description of the project site location and the affected program area [IPC 401 Application, § 7.1.1]. The Riverside Irrigation District and the project location are both visible in the map in Figure 7.2-1 of the 401 Application. The ROWQIP is designed to improve downstream water quality, and therefore conditions for beneficial uses, in waters that previously received highly degraded water.
(d) BMPs: A description of the water quality benefits that will be generated, the BMPs that will be used to generate water quality benefits, and applicable BMP quality standards;	• (5d): The ROWQIP describes how "phosphorus reductions" will be generated [IPC 401 Application, § 7.2.1.1.1] and describes the improved canal management as the BMP that will be used to generate those reductions [IPC 401 Application, § 7.2.1.1.3]. The detailed project design and operation information, as well as maintenance effectively serve as quality standards for this project [IP 401 Application, Exhibit 7.2-2: Riverside Operational Water-Quality Improvement Project (ROWQIP) development report].
(e) Trading ratios: A description of applicable trading ratios, the basis for each applicable trading ratio, including underlying assumptions for the ratio, and a statement indicating whether those ratios increase or decrease the size of a credit	• (5e): No trading ratios are explicitly identified for the ROWQIP, however the project includes an equivalency ratio, and an unidentified, but significant, net pollution reduction ratio [IPC 401

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obligation or the number of credits generated from an individual trading project; (f) Credits: A description of the credits needed to meet water quality-based requirements of an NPDES permit or 401 water quality certification, including: (A) Quantity and timing: The number of credits needed and any credit generation milestones, including a schedule for credit generation; (B) Methods used: How credits will be quantified, including the assumptions and inputs used to derive the number of credits; and (C) Duration of credits: A description of the length of time credits are expected to be used.	Application, § 7.2.1.1.2; Ex. 7.2-2 – Appendix 2; § 7.2.1.1.4.2]. • (5f): The 401 Application calculates the “dissolved oxygen supplementation” (in tons) needed to address DO concerns in Brownlee Reservoir and calculates an equivalent seasonal phosphorus load reduction amount using stoichiometry [IPC 401 Application, § 7.2.1.1.2]. The mass balance quantification method used, including assumptions and details on inputs, is described in the Application [IPC 401 Application, § 7.2.1.1.3; Ex 7.2-2-Appendix 3]. The time period of credit generation (duration) is “183 days beginning April 15 and extending to October 15”, which is twice the length of the DO critical period from July 1-September 7 [IPC 401 Application, § 7.2.1.1.2; Ex 7.2-2 Appendix 2]. Phosphorus reductions from the ROWQIP are counted daily and averaged over the irrigation season to generate an average annual load reduction. The time period of credit generation is “183 days beginning April 15 and extending to October 15” [IPC 401 Application, § 7.2.1.1.4.2]. Phosphorus reductions are generated during the irrigation season.
(g) Monitoring. The trading plan must include a description of the following: (A) Proposed methods and frequency of trading project BMP monitoring; and (B) Proposed methods and frequency of how water quality benefits generated by a trading project will be monitored;	• (5g): The 401 Application description of monitoring and reporting anticipates that “a detailed monitoring and reporting plan” will be submitted to ODEQ and IDEQ within 1 year of the new license issuance for the HCC” [IPC 401 Application, § 7.2.1.1.5]. This monitoring plan will include details on methods and frequency for monitoring the canal operations and for the phosphorus reductions that it generates. Exhibits 7.2-1 and 7.2-2 include information on monitoring, including methodologies, that has been completed in advance of the new license, and is expected to help form the basis of developing future monitoring documentation [IPC 401 Application, Exhibit 7.2-1: *Riverside Operational Water-Quality Improvement Project (ROWQIP), 2014 annual report*; IPC 401 Application, Exhibit 7.2-2: *Riverside Canal Water Quality Project Monitoring Status Report for 2011, 2012, and 2013*].
(h) Trading Plan Performance Verification: A description of how the entity will verify and document for each trading project that BMPs are conforming to applicable quality standards and credits are generated as planned; and	• (5h): The ROWQIP will include third party verification and associated reporting as required by ODEQ and IDEQ in the 401 certification [IPC 401 Application, § 7.2.1.1.5].

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(i) Tracking and Reporting: A description of how credit generation, acquisition and usage will be tracked and how this information will be made available to the public.	• (5i): The intent of the proposed ROWQIP is that annual reporting of credit generation, and how those credits relate to the compliance target, will be submitted to IDEQ and ODEQ on an annual basis. All documentation submitted to IDEQ and ODEQ would be available to the public. Further, the intent is that because there is an adaptive element inherent in the proposed project, reporting and tracking could be modified at the request of IDEQ or ODEQ as warranted by future project or national, state, or regional trading program developments. The current project proposal, which includes an adaptive element based on future developments, provides certainty that the ROWQIP will "ensure a level of quality consistency with regional and national nutrient trading programs" [IPC 401 Application, § 7.2.1.1.5].
(6) Adaptive Management: Trading plans must include a description of how monitoring and other information may be used over time to adjust trading projects and under what circumstances;	• (6): The ROWQIP acknowledges the multi-year timeframe of the contract and the variable nature of phosphorus load reductions. The ROWQIP therefore incorporates the ability to adaptively manage the program to reflect new knowledge and information as it emerges [IPC 401 Application, § 7.2.1.1.7].
(7) Trading Plan Revision: An approved trading plan must be revised during permit or 401 water quality certification renewal or if there is a change in circumstances that affects a trading plan element required by subsection (5) of this rule. Revised trading plans must be submitted to DEQ for review and approval and must be given an opportunity for public notice and comment. DEQ will reopen and modify the permit or 401 water quality certification for any revisions affecting an enforceable condition.	• (7): The ROWQIP contemplates that any proposed changes to canal operations (or other management to reduce phosphorus loads as well as to monitoring and reporting) would be subject to approval by the DEQs [IPC 401 Application, § 7.2.1.1.7].
340-039-0030 **Requirements for Trading Baselines** (1) Trading baseline must account for the following regulatory requirements applicable to the trading project at the time of trading project initiation:	• (1): In some instances, no baseline obligations exist: "If no regulatory requirements described in OAR 340-039-0030(1) exist or apply within the trading area, the trading plan may state that baseline is 'existing conditions.'" Trading IMD, § 5(II)(C). For the ROWQIP, the trading baseline is existing conditions—referred to here as the "Baseline Operations Flow" condition [IPC 401 Application, § 7.2.1.1.3.2]. Outside of the obligation to only withdraw water consistent with its water right, there is no current regulatory requirement for the operations or management of

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	Riverside Canal related to phosphorus or DO reductions.
(a) NPDES permit requirements;	• (1a): The 401 Application does not contemplate any interaction with a NPDES permit holder in the ROWQIP program area.
(b) Rules the Oregon Department of Agriculture issued for an agricultural water quality management area under OAR chapter 603 division 095;	• (1b): Oregon AgWQMP rules do not address irrigation canal operations.
(c) Rules the Oregon Board of Forestry issues under OAR chapter 629 divisions 610-680;	• (1c): Oregon BOF rules do not address irrigation canal operations.
(d) Requirements of a federal land management plan, or an agreement between a federal agency and the state;	• (1d): The ROWQIP project is based on a contract between two private parties, related to state law water right management.
(e) Requirements established in a Clean Water Act Section 401 water quality certification;	• (1e): The IMD notes that if a 401 license holder would like to generate credits, it would need to complete actions beyond mitigation conditions included in its 401 application [Trading IMD, § 5(I)(H)(iii)]. However, IPC will be generating phosphorus reductions to comply with its 401 obligation, so the baseline considerations that apply are those related to other nonpoint source generators of phosphorus reductions [Trading IMD, § § 5(I)(H)(iv)].
(f) Local ordinances;	(1f): No county and city regulations applicable to the ROWQIP trading area currently affirmatively require phosphorus reductions or improved canal operations.
(g) Tribal laws, rules, or permits; (h) Other applicable rules affecting nonpoint source requirements;	• (1g, h): The ROWQIP did not identify any tribal laws, rules or permits, or other currently applicable rules affecting nonpoint source requirements.
(i) Projects completed as part of compensatory mitigation, or projects required under a permit or approval issued under Clean Water Act section 404, or a supplemental environmental project used to settle a civil penalty imposed under OAR chapter 340 division 012 or the Clean Water Act; and	• (1i): IPC implemented ROWQIP; it was not planned or required for any other mitigation or permit.
(j) Regulatory requirements a designated management agency establishes to comply with a DEQ-issued TMDL, water quality management plan or another water pollution control plan adopted by rule or issued by order under ORS 468B.015 or 468B.110.	• (1j): Pursuant to the SR-HC TMDL, WQMP implementation plans can be issued by designated management agencies (DMAs). Relevant DMAs identified in the DEQ SR-HC TMDL WQMP include IPC, ODA, ODEQ, ODOF [SR-HC TMDL, § 6.1, Ch. 5]. The SR-HC TMDL "implementation plans" created by these DMAs incorporate and rely on existing regulatory mechanisms (e.g., AgWQMP area rules), but do not create stand-alone obligations for irrigation canal operations.

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(2) BMPs required to meet baseline requirements and BMPs used to generate additional water quality benefits and trade credits may be installed simultaneously.	• (2): The ROWQIP does not explicitly address this issue because since there are not baseline BMP requirements. As such, installation timing of BMPs for credit relative to baseline BMPs is not relevant.
340-039-0035 **Requirements for Trading Areas** (1) DEQ may establish trading areas in trading frameworks. (2) All trading areas must be consistent with any applicable TMDL water quality management plan, independent state water quality management plans, or trading framework.	• (1): inapplicable because no framework. • (2): The ROWQIP program area [IPC 401 Application, § 7.2.1.1.1] is consistent with Oregon's SR-HC TMDL water quality management plan (WQMP) [TMDL, § 6.1, Ch. 3]. The Oregon WQMP notes that one primary factor driving dissolved oxygen impacts in the Snake River is "oxygen demanding pollutants", which includes phosphorus.
340-039-0040 **Requirements for Credits** (1) Credits used for compliance with NPDES permit and 401 water quality certification requirements must be generated within the trading area of an approved trading plan. (2) A credit may not be used to meet a regulatory obligation by more than one entity at any given time. (3) Credits may be generated only from BMPs that result in water quality benefits above trading baseline requirements. (4) Credits generated under an approved trading plan may not include water quality benefits obtained with public conservation funds. Where public sources of funding are used for credit-generating activities, it is the entity's responsibility to demonstrate compliance with this requirement in its annual report. (5) Credits may be used for compliance with NPDES permit requirements and 401 water quality certifications once implementation of BMPs has been verified as consistent with applicable BMP quality standards according to OAR 340-039-0025(5)(h).	• (1): Only phosphorus reductions generated by the ROWQIP that contribute to phosphorus concentrations in agricultural drains will be eligible for use in the 401 [IPC 401 Application, § 7.2.1.1.7]. • (2): ROWQIP phosphorus reductions will only be used by IPC, and will be tracked accordingly [IPC 401 Application, § 7.2.1.1.5]. • (3): The ROWQIP is not currently subject to any regulatory baseline requirements. As noted above, baseline is equal to current conditions, and only credits generated above the Baseline Operations Flows condition can be used for compliance [IPC 401 Application, § 7.2.1.1.3.2]. • (4): ROWQIP operations associated with phosphorus reductions will not be funded via public conservation funds [IPC 401 Application, § 7.2.1.1.6]: "In 2014, IPC and Riverside signed a binding contract that identifies operational requirements for Riverside, and financial compensation by IPC to ensure the project is operated in a way that results in phosphorus load reductions." Additionally, IPC's intent is to demonstrate compliance with this requirement in its annual report. • (5): IPC expects that review and approval of its application, including all associated ROWQIP information and any required verification of the project, will serve to demonstrate consistency

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(6) Credits may be generated from BMPs installed before DEQ approves a trading plan if BMPs are verified as having been implemented consistent with BMP quality standards identified in a subsequently approved trading plan and are functioning effectively.	with BMP quality standards. • (6): The ROWQIP was implemented in 2014, in advance of 401 certification because "early implementation not only ensures that realization of benefits will begin immediately upon issuance of the HCC CWA § 401 certification, but also that long-term benefits can begin to accrue prior to § 401 issuance." [IPC 401 Application, § 7.2.1.1.6, Implementation Timeline]. Explicit quality standards for irrigation canal operations do not exist, however, monitoring data will be able to demonstrate that the equipment and operations are functioning effectively, and achieving expected reductions.
340-039-0043 **Requirements for Trading Ratios** (1) Water quality trades must include one or more trading ratios that apply to credits. Ratio components and underlying assumptions must be clearly documented in the trading plan. (2) Trading ratios may be used to account for variables associated with a trading project including the following: (a) Attenuation of a water quality benefit between the location where credit-generating BMPs occur and the point of use; (b) Pollutant equivalency; (c) Uncertainty of BMP performance or water quality benefit measurement or estimate; (d) Types of risk not associated with BMP performance;	• (1): The ROWQIP includes two ratio components, which affect the size of the offset obligation, and the value of benefits from the ROWQIP. The assumptions underlying these ratios are described in the 401 application [§ 7.2]. • (2a): The 401 Application explains in detail why the ROWQIP does not include an attenuation ratio between ROWQIP site and the point of use (Brownlee Reservoir) [IPC 401 Application, 7.2-2 Exhibit: IPC Equivalent Seasonal Phosphorus Load Reduction]. • (2b): The benefits from the ROWQIP project are measured in pounds of total phosphorus, which have been translated into an equivalent annual DO supplementation using stoichiometric ratios. IPC's oxygen allocation (1,125 tons of oxygen) equates to approximately 15,000 pounds of total phosphorus [IPC 401 Application, § 7.2.1.1.2; Exhibit 7.2-2-Appendix 2], and because phosphorus is a conservative constituent, the majority of upstream phosphorus reductions can be expected to have a direct effect on DO conditions in Brownlee Reservoir. • (2c, d): The modeled reductions from the ROWQIP are based on data measured in 2014 and other years [IPC 401 Application, § 7.2.1.1.3.2; 7.1.1.4], which limits uncertainty compared to BMP's without measured data. A 13% margin of safety was used in developing the load allocations and capacity for the TMDL,

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(e) Time lag after BMP installation before a BMP produces full water quality benefit; (f) Credit for trading projects located in priority areas; or (g) Credit retirement to ensure a net reduction in water pollution.	including phosphorus allocations [SR-HC TMDL, §4.0.2.3]. • (2e): N/A. Anticipated compliance is expected immediately upon installation of ROWQIP; early implementation in 2014 further avoids any time lag in the production of phosphorus reductions. No time lag ratio required. • (2f): N/A. IPC does not seek a ratio for implementing the ROWQIP in a priority area. • (2g): Load reductions above the compliance target, which have been demonstrated to potentially occur under this program, are implicitly part of the ROWRID. The SR-HC TMDL allocated IPC 1,125 tons of DO [SR-HC TMDL, §4.0.2.8]. After converting the DO load to phosphorus, IPC's load allocation is equivalent to approximately 15,000 lbs [IPC 401 Application, §§ 7.2.1.1.2; Ex. 7.2-2 – Appendix 2]. In comparison, the total phosphorus reduction associated with the ROWQIP in 2014 was 31,920 lbs [IPC 401 Application, §§ 7.2.1.1.4.2]. This extra benefit—which was more than 2:1 in 2014—is not being claimed by IPC, and is equivalent to retirement to ensure a net reduction in water pollution.

3. ODEQ Request for Additional Information on April 5, 2016

This request covered levels of toxics in the water column, operations and harmful algal blooms.

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ODEQ Request #1

Water Column Toxics:

DEQ has been reviewing the information on toxic pollutants provided in the December 1, 2015 application for Section 401 certification. DEQ has been unable to reconcile results in various tables in Exhibit 6.6-1. For example, Table 10 lists endosulfan as a parameter that was evaluated in the 2010 and 2011 sampling events in Brownlee Reservoir. Table 10 notes the maximum concentrations and MDL for endosulfan with a "dash." No Note is provided to explain the meaning of the dash symbol. Further, on Table E4, endosulfan is listed with non-detect results and an MDL recorded.

Please provide a table of the results for the toxic parameters listed below, including site name (include data for each location sampled), parameter name, detection limit (MDL), limit of quantification (LOQ), result and any flags. Results should be summarized as follows:

Parameter not detected below the detection level (MDL) = ND
Values between the MDL and LOQ = flag as an estimate
Values above the LOQ = Validated results

Please provide this information for the following parameters:

Atrazine
Desethyl atrazine
Chlordane
Chlorpyrifos
Dieldrin
DDT
4,4' DDE
Endosulfan
Endosulfan Alpha (reported as endosulfan I)
Endosulfan Beta (reported as endosulfan II)
Endosulfan sulfate
Dioxin (2,3,7,8-TCDD)
Polychlorinated Biphenyls (PCBs)

IPC Response

Exhibit 6.6-1 summarized results of almost 500 individual toxic organic compounds. Four different analytical laboratories were utilized, each selected according to targeted parameters and/or detection limit requirements. Many of the results for the list of parameters were captured through a series of screens where one laboratory procedure returns results for a number of similar compounds. As a result of these scans some parameters were reported by more than one laboratory, each with potentially varying LOQs and MDLs.

The approach used by the contractor in Exhibit 6.6-1 to summarize the results was to focus only on the parameters that were detected, either above the LOQ, or below the LOQ and above the MDL, in any of the samples by any of the laboratories. In addition, the approach was to focus on the maximum concentration of these detected parameters in the hypolimnion and discharge for the summaries. The primary summaries of these concentrations are presented in Table 9 and Table 10 in Exhibit 6.6-1 and, as ODEQ points out in their request above, both tables include “dashes” whose meanings are not defined in the table notes. IPC reviewed the approach taken in summarizing the data and writing the report with the contractor and confirmed that intent of the “dash” varies in Tables 9 and 10 as follows:

- the dashes in Table 9 under the “EPA Benchmarks” columns, and in Table 10 the “OR Aquatic-Life Criteria” and “OR Human Health Criteria” columns, indicate that no benchmarks or criteria had been established for those compounds by the date the report was issued;
- the dashes in Table 10 under the “Actual MDL” column indicate that MDLs were not reported by the laboratory for these parameters; and
- the dash in Table 10 under the “Hypolimnion” and “Discharge” columns indicates that results were reported for an isomer, metabolite or related compound of the parameter, which is presented in the next row.

IPC also worked with the contractor to re-summarize the raw laboratory results in the specific way requested by ODEQ. Because results for some of the requested compounds requested by ODEQ may have been “not detected” from two or more different laboratories with different LOQs or MDLs the approach IPC and the contractor initiated to respond to ODEQ’s request was to develop a separate table for each lab showing all requested parameters. At this time, only one of the four necessary tables, (i.e., TDI-Brooks Laboratory) has been completed (Table 1). To complete the remaining 3 tables IPC plans to reengage the contractor to re-summarize the raw laboratory reports to match ODEQ’s request. The contractor indicates this effort may take an additional 2 weeks to complete and IPC will provide them to ODEQ when complete.

Table 1 incorporates ODEQ’s request to use specific flags and notations (listed below). In order to match with the results reported by the laboratory, IPC included one additional flag to the requested items from ODEQ. Therefore the results in Table 1 are summarized as:

- Parameter not detected below the detection level (MDL) = “ND”
- Parameter detected below the detection level (MDL) = flag as “J”
- Values between the MDL and LOQ = flag as an estimate “E”
- Values above the LOQ = Validated results “V”

Table 1. DRAFT Summarized results in from TDI-Brooks laboratory (in ng/L) for selected toxic organic compounds requested by ODEQ via email on April 5, 2016. Parameters were measured in 2011 in the Brownlee Reservoir hypolimnion (IPC-1, IPC-2, IPC-3 and IPC-3 replicate) and Brownlee Reservoir Discharge (IPC-4, IPC-5 and IPC-6).

TDI-Brooks DRAFT	IPC-1	Flag	IPC-2	Flag	IPC-3	Flag	IPC-3 rep	Flag	IPC-4	Flag	IPC-5	Flag	IPC-6	Flag	MDL[1]	LOQ[2]
Atrazine	--		--		--		--		--		--		--		--	--
Desethyl atrazine	--		--		--		--		--		--		--		--	--
Chlordane[3]	ND		ND		ND		ND		0.82		ND		ND		--	--
Alpha-Chlordane	ND		ND		ND		ND		0.82		ND		ND		0.70	5
Gamma-Chlordane	ND		ND		ND		ND		ND		ND		ND		0.89	5
Chlorpyrifos	0.67	J	0.94	E	ND		0.89	E	0.5	J	0.55	J	0.67	J	0.86	5
Dieldrin	ND		ND		ND		ND		ND		ND		ND		0.77	5
DDT[4]	ND		0.07		0.11		0.09		ND		ND		0.15		--	--
2,4'-DDT	ND		ND		ND		ND		ND		ND		ND		0.80	5
4,4'-DDT	ND		ND		ND		ND		ND		ND		ND		0.63	5
4,4'-DDE	ND		0.07	J	0.11	J	0.09	J	ND		ND		0.15	J	0.74	5
Endosulfan	--		--		--		--		--		--		--		--	--
Endosulfan Alpha (reported as endosulfan I)	ND		ND		ND		ND		ND		ND		ND		0.70	5
Endosulfan Beta (reported as endosulfan II)	ND		ND		ND		ND		ND		ND		ND		0.61	5
Endosulfan sulfate	ND		ND		ND		ND		0.10	J	ND		0.10	J	0.78	5
Dioxin (2,3,7,8-TCDD)	--		--		--		--		--		--		--		--	--
Polychlorinated Biphenyls (PCBs)	--		--		--		--		--		--		--		--	--

Notes: [1]MDL is the lower method detection level provided by the laboratory. [2]LOQ is the Limit of Quantification reported by the lab. [3]Chlordane was reported by TDI-Brooks as "Total Chlordane" as the sum of Alpha-Chlordane and Gamma-Chlordane. No flags or MDL/LOQ values were included with the Total Chlordane result from TDI-Brooks. [4]DDT was reported by TDI-Brooks as "Total DDT" as the sum of all DDT and DDT breakdown products (DDE and DDD). No flags or LOQ/MDL values were included with the Total DDT result from TDI-Brooks. A dash (--) in the result columns indicates the analysis for that specific compound or class of compounds requested by ODEQ was not run or reported by this lab. A dash (--) in the LOQ/MDL columns indicates no values were provided by this lab because the result was reported as the sum of other analyses. ND indicates "non-detect" meaning the parameter was not detected below the MDL, as requested by ODEQ. A Flag of "E" indicates an estimated value detected above the MDL but below the LOQ, as requested by ODEQ. A Flag of J indicates the parameter was detected below the MDL.

ODEQ Request #2

Proposed Operations:

The December 1, 2015 application doesn't provide information about proposed project operations. Please provide information to DEQ showing that the distribution of flows that the 401 application analyses are based on will not change under proposed project operations.

IPC Response

In the HCC 401 certification application, IPC used a combination of historic data analysis and modeling simulations to describe and evaluate potential future conditions for water quality relative to the HCC. Both historic data analysis and model simulation results are representative of future conditions anticipated under a new FERC license for the following reasons.

First, because historic operations (since 1991) are very similar to those proposed by IPC in its license application, use of water quality data from the same time period to describe expected future conditions for the purposes of the 401 application is reasonable. Tables B-1, B-3, and B-4 of Exhibit B *Statement of Project Operation and Resource Utilization* in IPC's HCC FERC license application summarize the differences between current license operational constraints and IPC's proposed operations constraints. Relative to Brownlee Reservoir, the primary difference between IPC's proposal and the current license relates to daily reservoir fluctuations and target reservoir surface elevations. However, even though the current license contains no limitations relative to those conditions, IPC has voluntarily typically operated Brownlee Reservoir within those constraints since 1991. Therefore, historic water quality data collected since 1991 should be representative of IPC's proposed future operations.

Further, Table B-4 compares Hells Canyon Reservoir operations between current license constraints and IPC's proposed constraints. The primary difference between current and proposed operations for Hells Canyon Reservoir relates to downstream flows. Specifically, IPC's proposed operations relative to flows being released from Hells Canyon Dam vary to some degree from the current license, but are defined in a way that is more protective of fall Chinook than operating to the maximum limits of the current license. IPC has been operating within the constraints of the current license, while also operating within the constraints identified in its proposed operations since 1991, as a way to protect listed fall Chinook. In summary, because IPC's proposed operations of are very similar to how the HCC has been operated since 1991 under the current license constraints, and voluntary operations to protect resources such as listed fall Chinook and spawning resident fish in Brownlee Reservoir, historic water quality data and analyses in the 401 application is relevant and representative of future conditions.

Model simulations used in the 401 certification application were typically based on operational constraints identified in the FERC FEIS. While the FERC staff recommended operations were similar in many ways to IPC's proposed operations, 5 additional operational constraints were identified by FERC on pages 35 and 36 of the FEIS. For example, in model scenarios to evaluate future D.O. conditions, IPC used FERC FEIS proposed operations rather than IPC proposed operations. This was done to represent the most likely operational scenarios and constraints anticipated for the new license. This modeling approach of using FERC FEIS operations for D.O. scenarios in the 401 certification application ensures that analysis in the 401 certification application should not change under future operational constraints in the new license.

To ensure that ODEQ has a complete record of relevant information regarding potential future operations of the HCC and implications to analysis in the 401 certification application, below we have listed 3 documents that are publicly available as additional, supporting information. IPC can provide copies of these documents if necessary. The 3 reports support the conclusion that analyses in the HCC 401 certification application, which was based on measured historic and current conditions, as well as modeling using CE-QUAL-W2 models developed during the relicensing process produce results that are relevant to, and would not be expected to change under IPC's proposed operations or FERC's FEIS operations.

1). IPC HCC FERC License Application. Exhibit B. Statement of Project Operation and Resource Utilization.

This document details how IPC is proposing to operate the HCC in its new license application to FERC. Specifically, Table B-1, B-3, and B-4 compare current operational constraints with proposed operational constraints for each of the 3 HCC reservoirs.

Table B-1 provides a summary of how proposed operations compare with current license operations for Brownlee Reservoir. In general, the proposed operations, and historic operations are similar in respect to basic operational constraints such as reservoir elevation, minimum flows, flow fluctuation rates, and flood control requirements.

Two differences between current operations and proposed operations are apparent. First, daily reservoir fluctuations are not limited for Brownlee and Oxbow reservoirs in the current license, while proposed operations define limits. While the current license does not contain daily water level constraints, IPC has been voluntarily operating under daily reservoir fluctuations similar to those contained in the proposed operations description to protect resident fish resources in the reservoirs for approximately the past 15 years. Second, the current license does not contain flow limitations at the HCC outflow relative to IPC's voluntary fall Chinook protection plan. However, despite the fact that the current license does not require fall Chinook protection plan flows, IPC has been voluntarily implementing the plan since 1991. It is more restrictive of flows downstream of Hells Canyon Dam during fall Chinook spawning than current license requirements. Therefore, historic data collected since 1991, and all modeling of operations under historic flows, proposed flows, or FEIS flows would be similar.

2). Technical Report Appendix E.1-4: Project Hydrology and Hydraulic Models applied to the Hells Canyon Reach of the Snake River. Technical Appendix to the IPC HCC FERC License Application.

This Technical Appendix to the FERC license contains 7 chapters describing how models were developed and used for analyses in the FERC license. This report is relevant to the 401 certification application because the same models, or models developed in a similar way were used in 401 certification application analyses. This report details the range of flow distributions and how they were calculated and applied to analyses based on categories of flow year. In summary, the range of models developed and used for analyses in the FERC license application, as well as the 401 certification application are relevant, and will not change under proposed project operations.

3). Responses to FERC Additional Information Request OP-2, Current Operations Scenario.

This report was specifically developed to address FERC's concern that, "Your license application did not provide supporting evidence that your proposed operation is the same as your current operations. Therefore, please clarify your proposed May through August Brownlee reservoir operation in light of ODFW's comments, and compare and contrast this operation with recent typical operations." IPC's analysis relative to this question concluded that comparing current operations to proposed operations did not represent a change that would significantly affect analyses and conclusions reached under current operations modeling scenarios.

ODEQ Request #3

Harmful Algal Blooms:

Table 6.4-2 (Page 114 of the December 1, 2015 application) provides the mean cell density for cynaobacteria excluding Aphanizomenon flos-aquae. How was the mean calculated? Did IPC integrate samples from depths for the calculation? Is the method to calculate the mean density included in the Appendices to the New License Application?

IPC Response

The mean cell density for cyanbacteria excluding Aphanizomenon flos-aquae in Table 6.4-2 (Page 114 of the December 1, 2015 application) are data reported by Myers et al. 2003 (Final License Application: Technical Report E. 2.2-2; Table 18, Table 19, Table 21). These data were reported for surface samples collected as discreet grab sample at 0.3 m depth using a Van Dorn sampler (pages 11 and 12 in Myers et al 2003). The calculation did not integrate samples at various depths, but used only samples from the 0.3 m depth. Myers et al. (2003)In the 401 application, reported results in cells per liter. The densities reported in the 401 application are reported as cells per milliliter to correspond to the Oregon Health Authority guideline. The conversion was done by dividing the Myers et al. 2003 densities by 1000.

ODEQ Request #1

Water Column Toxics:

DEQ has been reviewing the information on toxic pollutants provided in the December 1, 2015 application for Section 401 certification. DEQ has been unable to reconcile results in various tables in Exhibit 6.6-1. For example, Table 10 lists endosulfan as a parameter that was evaluated in the 2010 and 2011 sampling events in Brownlee Reservoir. Table 10 notes the maximum concentrations and MDL for endosulfan with a “dash.” No Note is provided to explain the meaning of the dash symbol. Further, on Table E4, endosulfan is listed with non-detect results and an MDL recorded.

Please provide a table of the results for the toxic parameters listed below, including site name (include data for each location sampled), parameter name, detection limit (MDL), limit of quantification (LOQ), result and any flags. Results should be summarized as follows:

Parameter not detected below the detection level (MDL) = ND
Values between the MDL and LOQ = flag as an estimate
Values above the LOQ = Validated results

Please provide this information for the following parameters:

Atrazine
Desethyl atrazine
Chlordane
Chlorpyrifos
Dieldrin
DDT
4,4’ DDE
Endosulfan
Endosulfan Alpha (reported as endosulfan I)
Endosulfan Beta (reported as endosulfan II)
Endosulfan sulfate
Dioxin (2,3,7,8-TCDD)
Polychlorinated Biphenyls (PCBs)

IPC Response

This Revised Table 1 replaces the draft Table 1 in IPCs response to this request on 04/15/2016

Table 1 incorporates ODEQ’s request to use specific flags and notations (listed below). In order to match with the results reported by the laboratory, IPC included one additional flag to the requested items from ODEQ. Therefore the results in Table 1 are summarized as:

- Parameter not detected below the detection level (MDL) = “ND”
- Parameter detected below the detection level (MDL) = flag as “J”
- Values between the MDL and LOQ = flag as an estimate “E”
- Values above the LOQ = Validated results “V”

Table 1. Summarized results (in ng/L, unless otherwise noted) for selected toxic organic compounds requested by ODEQ via email on April 5, 2016. Parameters were measured in 2011 in the Brownlee Reservoir hypolimnion (IPC-1, IPC-2, IPC-3 and IPC-3 replicate) and Brownlee Reservoir Discharge (IPC-4, IPC-5 and IPC-6).

Result by TDI-Brooks [except as noted]	IPC-1	Flag	IPC-2	Flag	IPC-3	Flag	IPC-3 rep	Flag	IPC-4	Flag	IPC-5	Flag	IPC-6	Flag	MDL[1]	LOQ[2]
Atrazine [UI][3]	ND		ND		ND		ND		ND		14	E	14	E	--	25
Desethyl atrazine [UI]	ND		ND		ND		ND		ND		30	V	30	V	--	25
Chlordane[4]	ND		ND		ND		ND		0.82		ND		ND		--	--
Alpha-Chlordane	ND		ND		ND		ND		0.82	E	ND		ND		0.70	5
Gamma-Chlordane	ND		ND		ND		ND		ND		ND		ND		0.89	5
Chlorpyrifos	0.67	J	0.94	E	ND		0.89	E	0.5	J	0.55	J	0.67	J	0.86	5
Dieldrin	ND		ND		ND		ND		ND		ND		ND		0.77	5
Dieldrin [Pace][5]	ND		ND		ND		ND		0.93	E	0.71	E	ND		0.52	10
DDT[6]	ND		0.07		0.11		0.09		ND		ND		0.15		--	--
2,4'-DDT	ND		ND		ND		ND		ND		ND		ND		0.80	5
4,4'-DDT	ND		ND		ND		ND		ND		ND		ND		0.63	5
4,4'-DDE	ND		0.07	J	0.11	J	0.09	J	ND		ND		0.15	J	0.74	5
4,4'-DDE [Pace]	ND		ND		ND		ND		ND		1.5	E	ND		0.94	10
Endosulfan	---		--		--		--		--		--		--		--	--
Endosulfan Alpha (reported as endosulfan I)	ND		ND		ND		ND		ND		ND		ND		0.70	5
Endosulfan Beta (reported as endosulfan II)	ND		ND		ND		ND		ND		ND		ND		0.61	5
Endosulfan sulfate	ND		ND		ND		ND		0.10	J	ND		0.10	J	0.78	5
Dioxin (2,3,7,8-TCDD) [Pace]	ND		ND		ND		ND		ND		ND		ND		--	10pg/L
Polychlorinated Biphenyls (PCBs) [Pace]	ND		ND		ND		ND		ND		ND		ND		--	100

Notes: [1]MDL is the lower method detection level provided by the laboratory. [2]LOQ is the Limit of Quantification reported by the lab. [3]UI is University of Idaho Analytical Sciences Laboratory, Moscow, Idaho. [4]Chlordane was reported by TDI-Brooks as "Total Chlordane" as the sum of Alpha-Chlordane and Gamma-Chlordane. No flags or MDL/LOQ values were included with the Total Chlordane result from TDI-Brooks. [5]Pace is Pace Analytical Services, Inc. Minneapolis, Minnesota. [6]DDT was reported by TDI-Brooks as "Total DDT" as the sum of all DDT and DDT breakdown products (DDE and DDD). No flags or LOQ/MDL values were included with the Total DDT result from TDI-Brooks. A dash (--) in the result columns indicates the analysis for that specific compound requested by ODEQ was not run or reported by any laboratory. A dash (--) in the LOQ/MDL columns indicates no values were provided by laboratory because the result was reported as the sum of other analyses. ND indicates "non-detect" meaning the parameter was not detected below the MDL, as requested by ODEQ. A Flag of "E" indicates an estimated value detected above the MDL but below the LOQ, as requested by ODEQ. A Flag of J indicates the parameter was detected below the MDL.

As shown in Table 1, estimated concentrations for Deildrin and DDE were reported by both TDI-Brooks and Pace Analytical, and all reported results are provided. Where multiple labs reported "non-detects" only the lowest reporting limits are provided in the table. Three different Endosulfan parameters were analyzed by multiple laboratories. Unlike DDT and Chlordane, the three parameters were not summed by the laboratories, and therefore are not summed in this table.

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4. ODEQ Request for Additional Information in January 2016

In January 2016, the ODEQ requested additional information related to consistency of units in the SRSP proposal, cold-water refugia conditions and DO calculations. As part of IPC's response to the DO request a Microsoft (MS) Excel file titled "2004_2014HCCOutflowDODeficitData_022316.xlsx" was also provided and included with this submittal.

ODEQ Request Related to Consistency of Units in the SRSP

> The units aren't consistent between the application and Exhibit 7.1-1. Please identify the thermal load exceedance in the same units in the main section of the application as in Exhibit 7.1-1. Please clarify whether tributary attenuation is included in the thermal load exceedance estimates.
>
> The thermal load exceedance IPC needs to offset is different if the load is based on 13 or 13.3°C. If the target is 13.0°C, does IPC have sufficient project locations available?

IPC Response

Table 1: Cumulative thermal load to offset at HCC outflow depending on temperature criteria of 13.3 or 13°C, margin of safety, and HCC attenuation rates.

HCC Obligation		
Temperature Criteria (°C)	**13.3**	**13.0**
Cumulative Thermal Load Exceedance (kcal)	550,670,000,000	665,180,000,000
Margin of Safety (%)	10%	10%
Cumulative Thermal Load Exceedance w/ Margin of Safety Applied (kcal)	605,737,000,000	731,698,000,000
HCC Reservoir Attenuation Rate (%)	50%	50%
Cumulative Thermal Load to Offset at HCC Inflow (kcal)	**1,211,474,000,000**	**1,463,396,000,000**

Table 2: Total available supply of thermal benefits based on project type (instream or riparian). The potential thermal benefits reflect the total available supply in the watershed and are presented to facilitate the assessment of program feasibility. The values presented below do not represent the final SRSP composition.

The appropriate attenuation ratios are applied to the aggregate thermal benefit supply by project type. Feasibility of the program is dependent on total available thermal benefit supply being greater than thermal load offset need. Feasibility is discussed in greater detail in section 2.4 SRSP Feasibility Assessment and subsection 2.4.3 Project Site Level Thermal Benefits & Effect on Thermal Benefit Supply.

Potential Thermal Benefit Supply			
Program Component	**Instream**	**Riparian**	**Total Potential Supply**
Jul-Oct Mean Daily Thermal Benefit (kcal/day)	15,216,000,000	14,939,000,000	30,155,000,000
Jul-Oct Aggregate Thermal Benefit Supply (kcal)	1,849,767,000,000	1,799,455,000,000	3,649,222,000,000
Benefit Attenuation (%)	22%	25%	
Aggregate Thermal Benefit Supply at HCC Inflow (kcal)	**1,442,818,000,000**	**1,349,591,000,000**	**2,792,409,000,000**

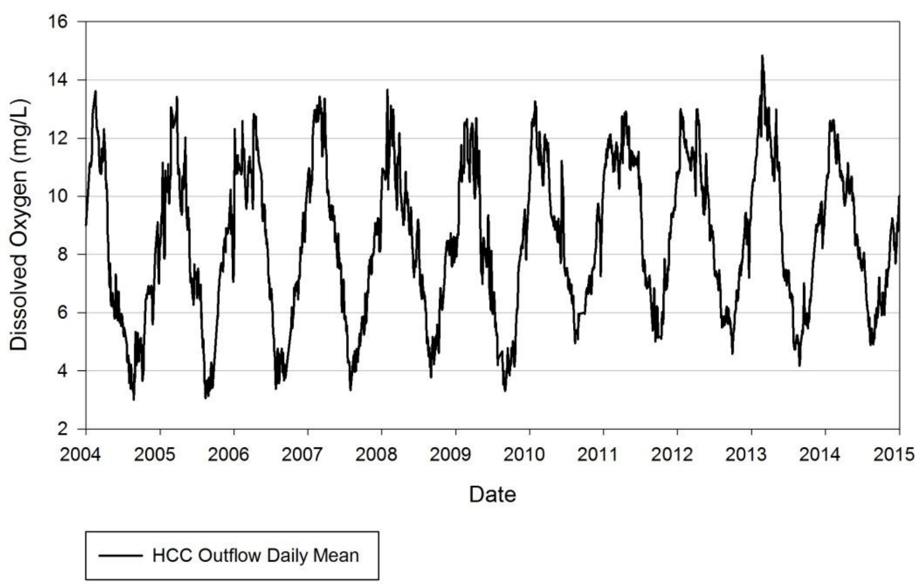
Oregon DEQ has requested clarification and additional details regarding the dissolved oxygen (DO) sections of IPC's current pending HCC 401 certification application (December 2015). Through discussions with ODEQ the information needed and provided in this document includes:

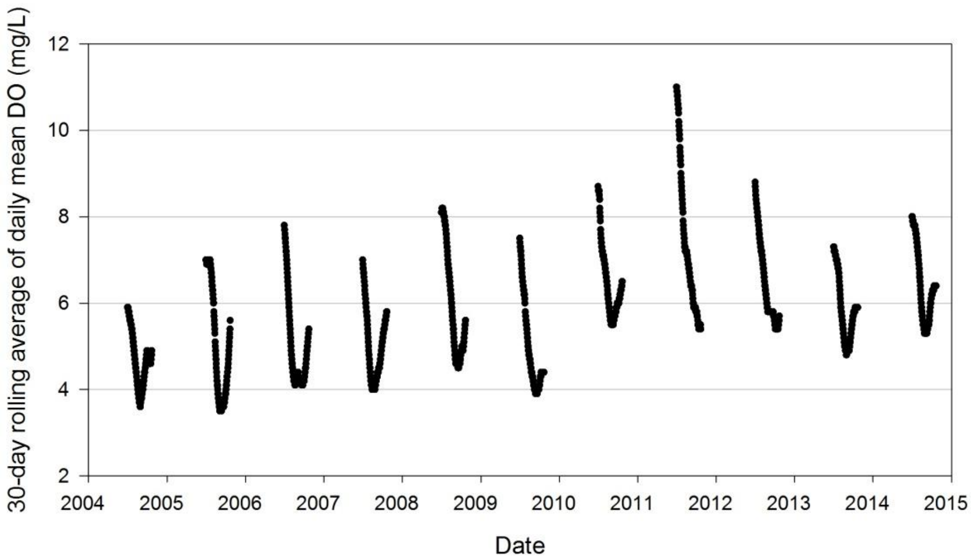
1. Calculation of the average annual DO deficit from criteria at the HCC outflow from years 2004-2014. The average annual DO deficit was calculated using the following three methodologies and criteria as developed in discussions with ODEQ.
    a. Using DO at the HCC outflow for the period of July 1 through October 22, from 2004 through 2014, calculate the DO deficit when measured data are compared to the 6.5 mg/L cool water aquatic life DO criteria. Using the cool water DO criteria as defined in Table 21 (340-041-0016 Dissolved Oxygen (3)), the dissolved oxygen may not fall below 6.5 mg/l as a 30-day mean minimum. Oregon Administrative rules (340-041-0002 definitions (39)) defines the 30 day mean minimum as follows: "Monthly (30-day) Mean Minimum" for dissolved oxygen means the minimum of the 30 consecutive-day floating averages of the calculated daily mean dissolved oxygen concentration, " with "daily mean" for dissolved oxygen defined at 340-041-0002(15) as "the numeric average of an adequate number of data to describe the variation in dissolved oxygen concentration throughout a day, including daily maximums and minimums. For calculating the mean, concentrations in excess of 100 percent of saturation are valued at the saturation concentration."
    b. Using DO at the HCC outflow for the period of October 23 through December 30th, from 2004 through 2014, calculate the DO deficit when measured data are compared to the water column values calculated from IGDO values, as described in the December 1, 2015 application for 401 certification. Using the salmonid spawning criteria 7-D time period described in Table 21, calculate the 7 day mean minimum as defined as OAR 340-041-002 Definitions (73). The 7 day mean minimum is defined as: "Weekly (seven-day) Mean Minimum" for dissolved oxygen means the minimum of the seven consecutive-day floating average of the calculated daily mean dissolved oxygen concentration."
    c. The 30-day or 7-day (depending on the period of interest) floating mean of the daily mean DO concentration was calculated for every day and subtracted from the criteria to calculate the deficit. The daily deficits (only for the days where DO was below criteria) were then averaged over the periods (cool water, salmonid spawning and July 1 through December 30) to calculate average DO deficit. The average over July 1 through December 30 represents the annual average DO deficit.
2. Presentations of new information relative to statistical trend analysis in HCC outflow DO.
3. Clarification of previously provided information relative to distributed aeration at Brownlee powerhouse and how much potential this proposal has for increasing DO at the HCC outflow. This includes discussion relative to how this potential DO increase compares to the annual average DO deficit.
4. Presentation of new information relative to upstream TMDL implementation and statistical trends in measured total phosphorus data from 2004-2015.

The period of record for all analysis of measured data is from 2004 through 2014. Starting the period in 2004 was selected because the SR-HC TMDL was approved in 2004. Because DO conditions could be expected to improve with SR-HC TMDL implementation, post-TMDL data are expected to be more reflective of current and future conditions than pre-TMDL data. Since an average over various periods is being calculated, any gaps in the 10 minute data were filled using linear interpolation. The resulting daily mean dataset (Figure 1) was then used for the remainder of the calculations. Corrections to the daily average values to account for DO saturation (as stated in the standards) were not required because the temperature conditions below Hells Canyon Dam result in 100% DO saturation values ranging from approximately 8 to 12 mg/L and all data considered in the summary of deficits is less than 6.5 mg/L.

During the low DO period of the cool water life and salmonid spawning periods there are statistically significant increasing trends in the 30-day (cool water life) and 7-day (salmonid spawning) HCC outflow DO conditions (Figure 2, Table 1).

Figure 1. Daily mean HCC outflow DO from 2004 through 2014





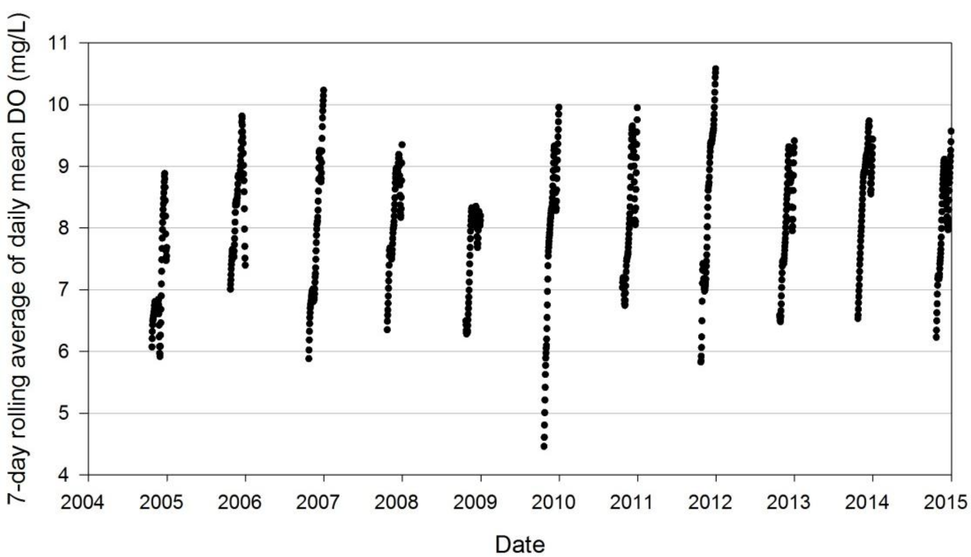


Figure 2. Data sets for trend analysis for the 30-day (top plot) or 7-day (bottom plot) rolling averages of the daily mean at the HCC outflow.

Table 1. Mann-Kendall trend analysis results of HCC outflow DO for the 30-day, or 7-day rolling average of the daily mean from July 1 through October 22 (cool water life period), or October 22 through December 30 (salmonid spawning period), respectively. Both trends are for the years over the 2004 through 2014 period.

Mann-Kendall trend results	Cool water life period	Salmonid spawning period
trend_n	1255	770
trend_years	11	11
kendall_sum	86618	23122
zscore	22.895	7.944
Zprob (p-value)	0	0
trend	increasing	increasing
season	seasonal	seasonal
sen_slope	0.188889	0.067376
lo_confidence slope	0.175	0.053796
hi_confidence slope	0.2	0.081089

The average annual DO deficit at the HCC outflow ranged from 1.0 to 1.4 mg/L depending on whether the average was calculated from the full-10 year dataset, or from the most recent 5 years of the dataset (Table 2). The average deficits in the more recent years (i.e., 2010-2014) are lower (i.e., 1.0 mg/L). This reflects the trends of increasing DO levels observed in the dataset (Figure 2 and 3).

Table 2. Average HCC outflow DO deficits in mg/L during the time frame since SR-HC TMDL approval (2004-2014). Deficits were calculated by subtracting the 30-day (cool water life low DO period July 1 through October 22) or 7-day (salmonid spawning low DO period October 23 through December 30) rolling average of the daily means from the criteria.

	Cool-water life average DO deficit from criteria (mg/L)	Salmonid Spawning average DO deficit from criteria (mg/L)	Annual average (July 1-Dec. 30) DO deficit from criteria (mg/L)
2004	1.8	2.4	2.1
2005	2.1	1.2	1.7
2006	1.9	1.8	1.9
2007	1.6	1.4	1.5
2008	1.4	1.8	1.6
2009	1.9	1.7	1.8
2010	0.6	1.6	1.0
2011	0.6	1.6	1.1
2012	0.8	1.5	1.1
2013	1.0	1.0	1.0
2014	0.7	1.4	1.0
Average 2004-2014	1.3	1.6	1.4
Average 2010-2014	0.7	1.4	1.0

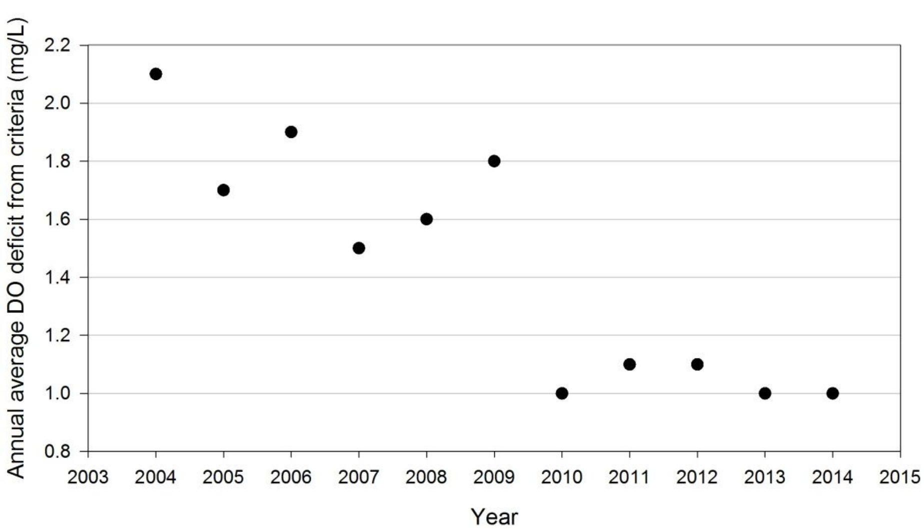


Figure 3. Average annual (July 1 through Dec 30) DO concentration deficit at HCC outflow. During the cold water aquatic life period these values are based on a 30-day rolling average of the daily means not less than 6.5 mg/L. During the salmonid spawning period these values are based on the 7-day rolling average of the daily means not less than 9.1-9.6 mg/L as developed in the 401 application.

The average deficit values of 1.4 mg/L (for all 10 years) and 1.0 mg/L (for the most recent 5 years) can be compared to the aeration potential of IPC's proposed distributed aeration system at the Brownlee Powerhouse. The purpose of this comparison is to explore whether there is reasonable assurance that the proposed aeration is capable of offsetting the low outflow DO, as quantified by the annual average deficit. To clarify the proposal, in the December 1 2015 401 application IPC proposed to operate the distributed aeration systems:

> ..within an adaptive management and monitoring framework to add as much additional oxygen to Brownlee outflow (and correspondingly Oxbow and Hells Canyon outflow, see Section 6.2 DO) as possible within the limitations of the current TDG criterion and considering Unit operation complications (e.g., vibrations, cavitation). *pg. 206.*

In the 401 application, IPC expressed confidence that the proposed operation could add 0.4 mg/L, at a minimum, to offset the calculated responsibility in the 401 application after full SR-HC implementation. In addition, based on Voith modeling information also presented in the 401 application, that the aeration systems have the potential to add 1.0 to 1.5 mg/L and remain below the 110% TDG criterion as represented in a well mixed downstream location (Figure 4). It is IPC's intention to operate the runners to add as much additional oxygen as possible within the current TDG limitations. Therefore IPC's proposal should result in the addition of enough oxygen to offset the 1.0 mg/L average annual average deficit as measured as an annual average net deficit from criteria at the HCC outflow over the July 1 through December 30 time period.

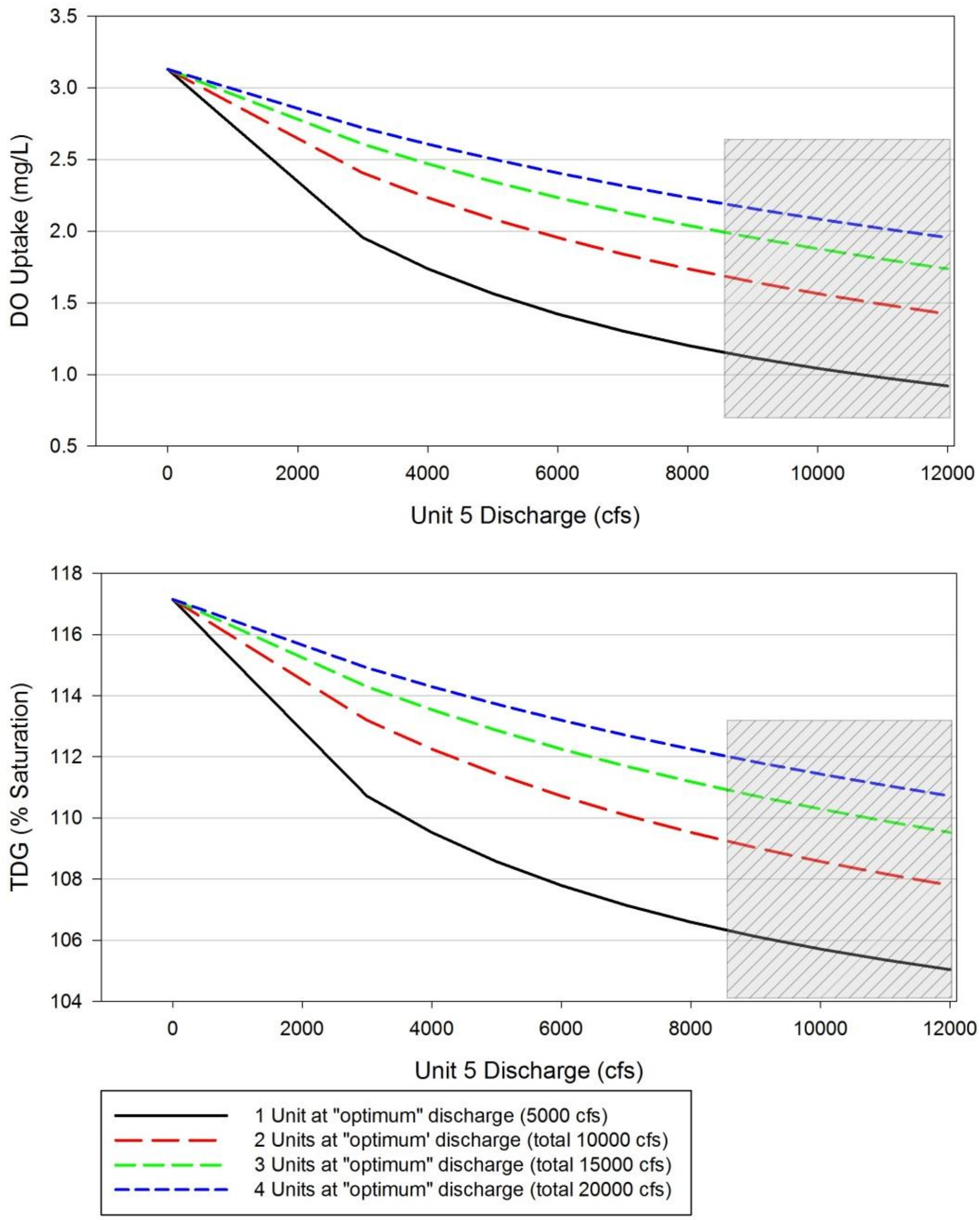


Figure 4 (Also presented as Figure 7.2-9 in the 401 application). Simple mixing scenarios combining the results of Voith Hydro's numerical modeling study with optimum discharge ranges for units 1 through 4 and unit 5 (shaded box shows typical discharge range of unit 5 when it is operating). These results represent a well mixed downstream condition under the initial incoming conditions of DO, TDG, temperature and tailwater elevation as described in the Voith Hydro modeling.

Since aeration will occur at the Brownlee powerhouse, additional demand and attenuation through Oxbow and Hells Canyon reservoirs must be considered. Comparison of recent (i.e., 2012) data collected at Brownlee, Oxbow and Hells Canyon outflows shows no consistent or significant additional demand through Oxbow and Hells Canyon reservoirs (see Figures 6.2-14, 6.2-16 and 6.2-17 of the December 2015 401 application). Therefore, on an annual average basis the majority of the additional oxygen added at Brownlee powerhouse should be realized at the HCC outflow. IPC is planning to monitor DO conditions at Hells Canyon Dam, and also in the immediate vicinity of Brownlee Dam during testing and implementation of the aeration system. The monitoring data will be used in an adaptive management framework to document and ensure that the aerating runners are providing the expected level of additional DO.

IPC also explored trends in Brownlee inflow total phosphorus concentrations as a way to estimate potential upstream TMDL implementation that has already occurred and provide technical support and reasonable assurance for the DO proposal. IPC analyzed measured changes in total phosphorus since 2004 for the time period May through September. The May through September period was used because that is the period within each year that the TMDL identified the target total phosphorus of 0.07 mg/L. Trend analyses were conducted using a Mann-Kendall seasonal trend analysis. Total phosphorus concentrations measured in the Snake River at river mile 345 (inflow to Brownlee Reservoir) since 2004 show a statistically significant decreasing trend (Table 3, Figure 5).

The total phosphorus trend analysis provides an indication of SR-HC TMDL implementation and/or other upstream TMDL implementation. While the SR-HC TMDL total phosphorus target of 0.07 mg/L is still exceeded at Brownlee inflow there is a clear decreasing trend. Using the technical basis developed in the SR-HC TMDL, this decreasing trend may be related to the improved HCC outflow DO conditions in the recent years.

Table 3. Mann-Kendall trend analysis results for Brownlee inflow total phosphorus data during the SR-HC TMDL seasonal period (May-September) over the 2004-2015 period.

Mann-Kendall Trend Results	Brownlee inflow total phosphorus
trend_n	125
trend_years	12
kendall_sum	-621
zscore	-6.48
Zprob (p-value)	0
trend	decreasing
season	seasonal
sen_slope	-0.004
lo_confidence slope	-0.005
hi_confidence slope	-0.00308

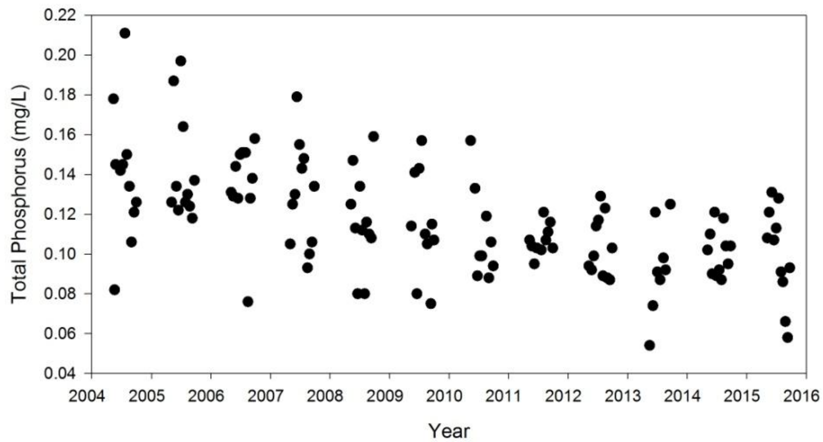


Figure 5. Brownlee inflow total phosphorus data measured approximately every 2 weeks during the SR-HC TMDL seasonal period (May-September) from 2004-2015. This data was used in the Mann-Kendall trend analysis in Table 2.

Oregon DEQ Data Request:

- If available, please provide the differences in degrees C based on the daily maximum temperatures for the following tributaries: Getta, Wolf, Deep, Divide and Imnaha (chosen because of their proximity to RM 202 on the Snake River).

Idaho Power Response:

The State of Oregon defines "Cold Water Refugia" (CWR) as "*those portions of a water body where or times during the diel temperature cycle when the water temperature is at least 2 degrees Celsius colder than the daily maximum temperature of the adjacent well-mixed flow of the water body*" (OAR 340-041-0002(10).

The following set of graphs compares daily temperature metrics at several tributaries in Hells Canyon to the daily maximum temperature in the Snake River. The two locations used for comparison to the Snake River are at River Miles (RM) 202 and RM 247. These two locations on the Snake River had the most complete data set relative to the information available for comparison to the tributaries. Figure 1 demonstrates that generally there is little difference in the daily maximum temperature between these two Snake River locations. There is some downstream warming as would be expected during the time period compared. The RM 202 (Figure 2) location is used as a comparison to tributaries that enter the Snake River between RM 206 and RM 190. The tributaries included in the comparison are Getta Creek (RM 205), Wolf Creek (RM 202), Deep Creek (RM 199), Divide Creek (RM 193) and the Imnaha River (RM 191). The RM 247 location (Figure 3) is used as a comparison to tributaries between RM 247 and RM 220. The tributaries used in this comparison are Deep Creek (RM 247), Granite Creek (RM 239), Sheep Creek (RM 229), Bernard Creek (RM 235), Three Creeks (RM 238), Kirkwood Creek (RM 220) and Temperance Creek (RM 223).

The temperature metrics from the tributaries used for comparison to the Snake River at these locations include daily minimum temperature, daily average temperature and daily maximum temperature. Because the CWR metric references the diel temperature cycle, these metrics offer an indication as to the extent during a diel cycle the tributaries meet the CWR definition. As indicated by the tributaries compared to RM 202 (Figure 2), all of the tributaries provide CWR during at least some portion of the day, with the exception of a few days in the middle of July, where all metrics exceed the -2 °C CWR definition. Generally, by mid August, the daily average temperatures start to drop below the -2 °C CWR definition which suggests that the majority of the diel cycle is providing thermal refugia. Finally, by around the first of September, all of the tributaries are providing CWR during the entire diel cycle.

The tributaries in Figure 3 demonstrate a much colder pattern relative to the Snake River. All of the tributaries with the exception of Temperance Creek and Kirkwood Creek provide significant CWR during all portions of the diel cycle. Temperance Creek and to a lesser extent Kirkwood Creek show patterns similar to those in the proximity of RM 202. The primary difference for the tributaries that meet the

CWR during the entire period is that they originate in high elevation headwaters associated with the Seven Devils Mountains of Idaho. These tributaries are relatively high gradient basins. As such, they originate in a much cooler thermal regime than the lower elevation tributaries that are not directly associated with those higher elevations. Even though Temperance Creek is in this section of river, it is an Oregon tributary, not associated with the elevation or gradient as those on the Idaho side. Kirkwood Creek is somewhat intermediate, because it originates toward the northern end of the Seven Devils Mountains at a slightly lower elevation. There are multiple drainages on the Idaho side of the Snake River between RM 247 and RM 220 that are associated with this high elevation run-off (see Exhibit 6.1-2).

This comparison demonstrates that overall, perennial tributaries in the Hells Canyon reach of the Snake River provide some level of thermal refugia based on surface water temperature. The component that is not captured in these comparisons is the level of ground water that is contributed through the alluvial fans of these drainages that would not be reflected in the surface flow. Based on the recent literature (Ebersole et al. 2015)[1] many tributaries, even those with dry channels, provide significant cold-water patches in mainstem rivers through hyporheic and groundwater upwelling during the time of year with the warmest water temperatures. It is likely that the subsurface flow associated with the alluvial fans at all of the tributaries contribute to CWR at some level.

[1] Ebersole, J.L., P.J. Wigington, Jr, S.G. Leibowitz, R.L. Comeleo, and J. VanSickle. 2015. Predicting the occurrence of cold-water patches at intermittent and ephemeral tributary confluences with warm rivers. Freshwater Science 34:111-124.

Figure 1. A comparison between daily maximum temperatures at RM 202 and RM 247during the period of comparison of various Snake River tributaries to the Snake River relative to cold water refugia.

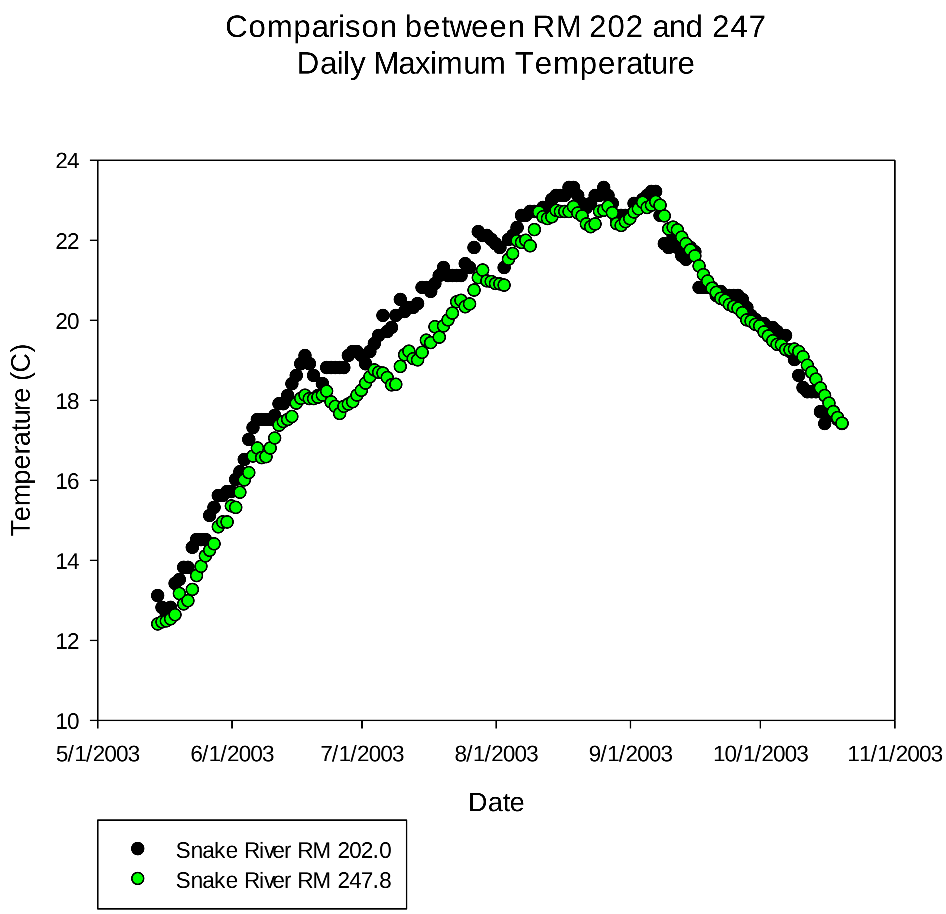
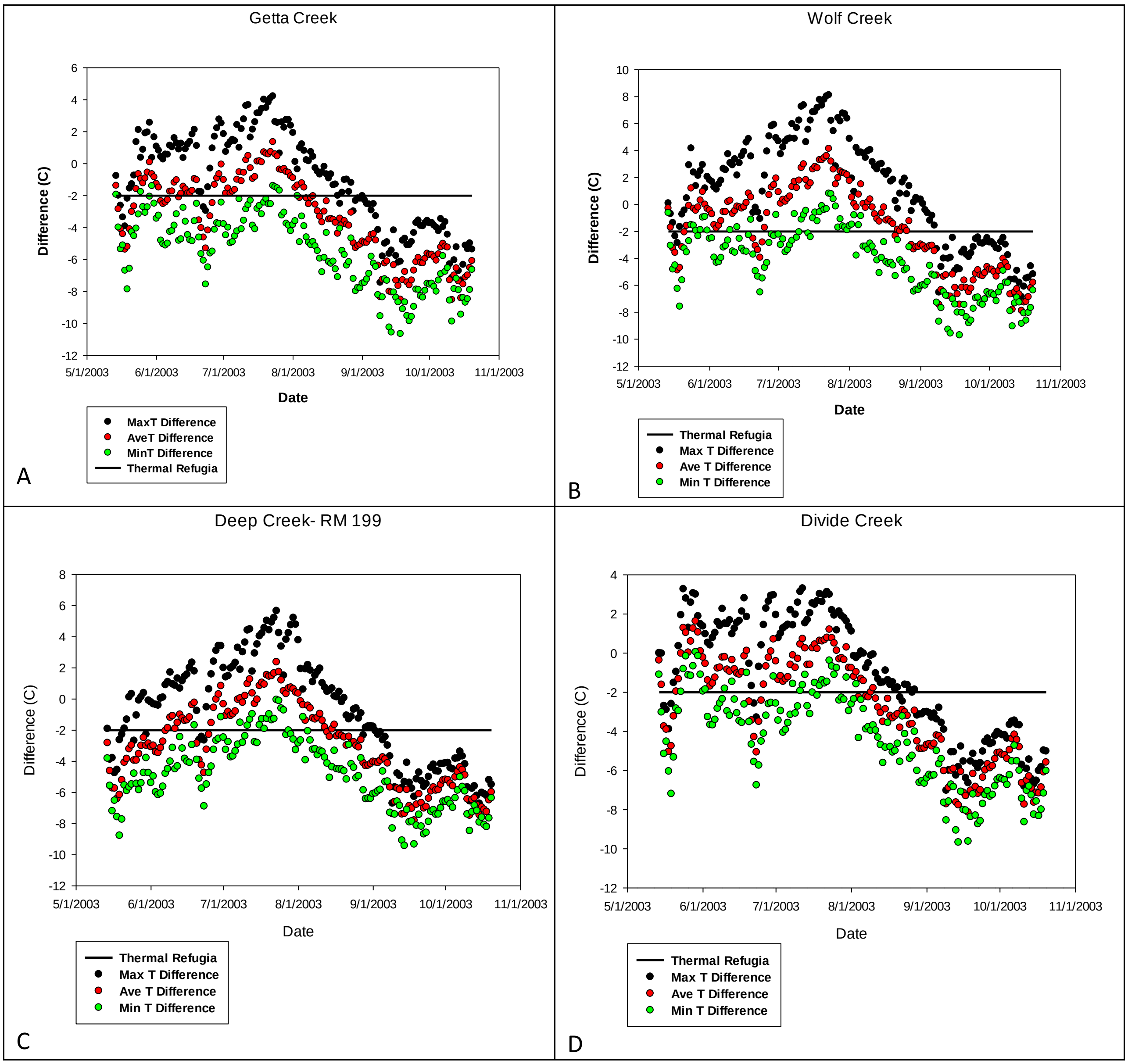
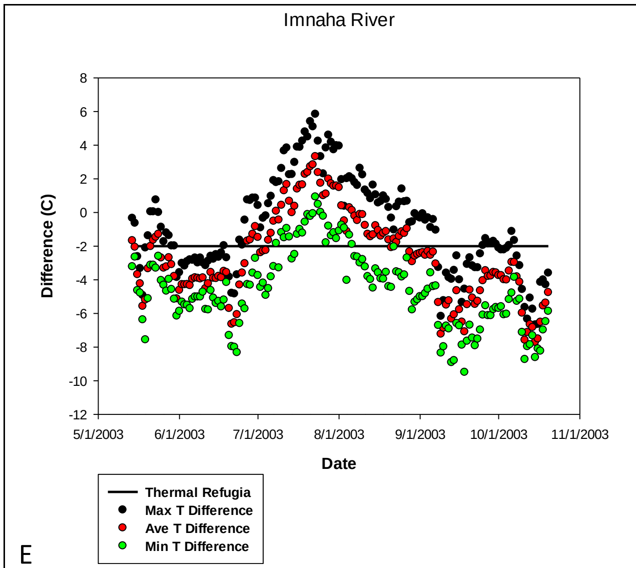
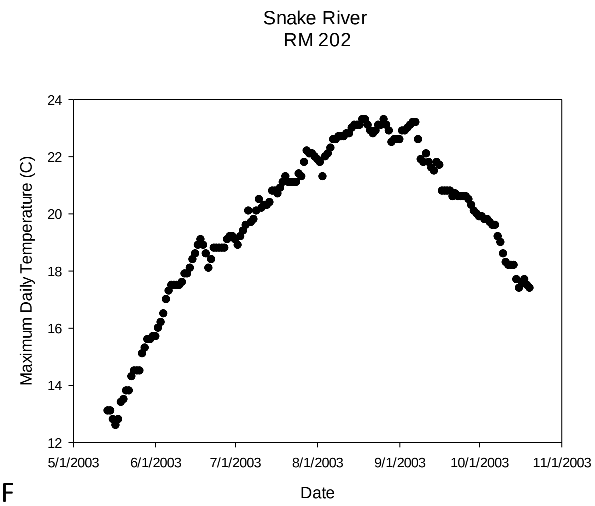


Figure 2. A comparison (represented by the difference in °C) between the daily maximum temperature in the Snake River at **River Mile (RM) 202** (Graph H) and the corresponding daily maximum, average and minimum temperatures at A. Getta Creek (RM 205), B. Wolf Creek (RM 202), C. Deep Creek (RM 199), D. Divide Creek (RM 193) and the E. Imnaha River (RM 191). A negative value represents the tributary daily maximum temperature being cooler than the corresponding mainstem Snake River.



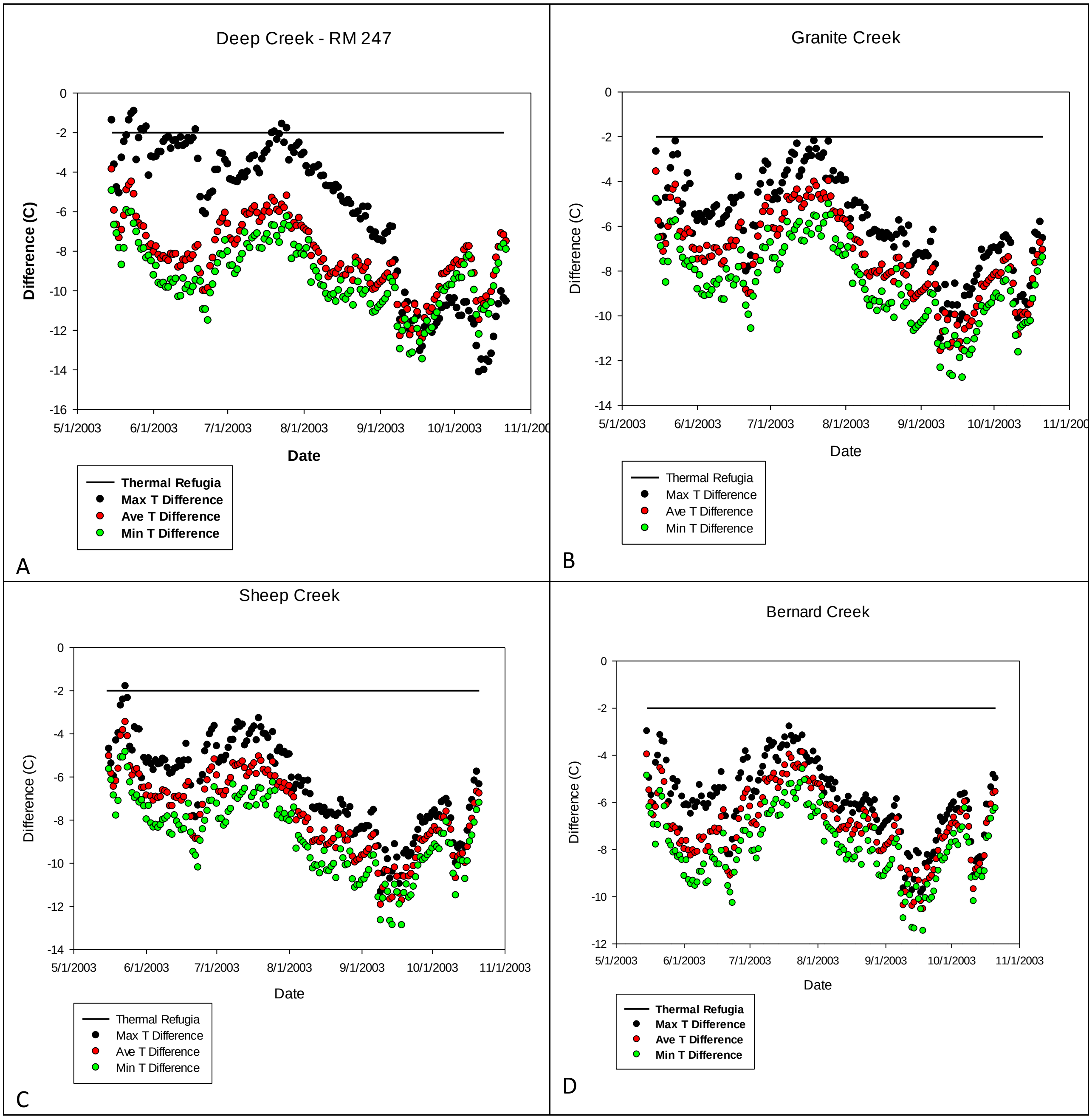

Imnaha River
8
6
4
2
0
-2
-4
-6
-8
-10
-12
Difference (C)
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Thermal Refugia
Max T Difference
Ave T Difference
Min T Difference

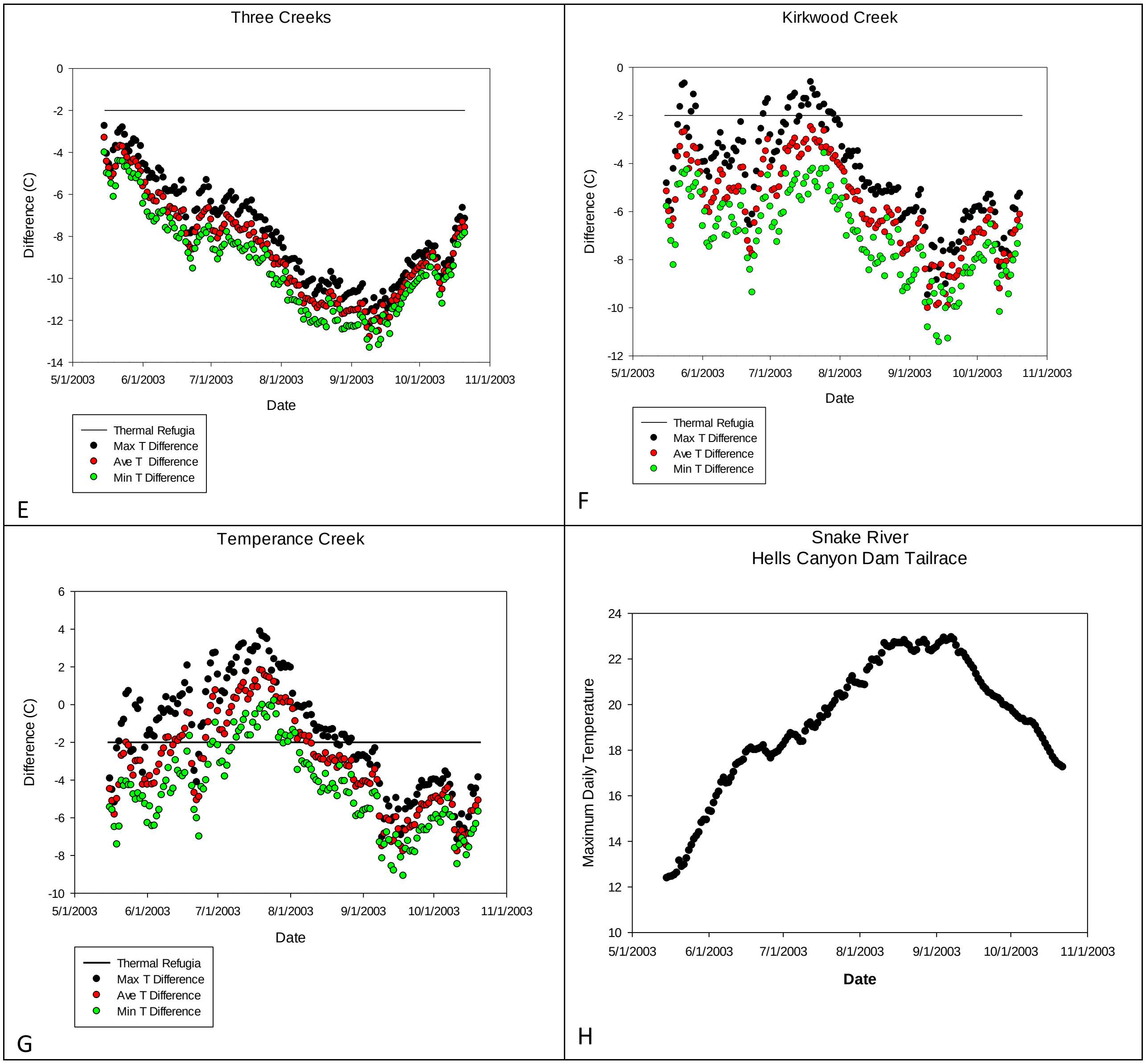
E


Snake River
RM 202
24
22
20
18
16
14
12
Maximum Daily Temperature (C)
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date

F

Figure 3. A comparison (represented by the difference in °C) between the daily maximum temperature in the Snake River at Hells Canyon Dam **River Mile (RM) 247.8** (Graph H) and the corresponding daily maximum, average and minimum temperatures at A. Deep Creek (RM 247), B. Granite Creek (RM 239), C. Sheep Creek (RM 229), D. Bernard Creek (RM 235), E. Three Creeks (RM 238), F. Kirkwood Creek (RM 220) and G. Temperance Creek (RM 223). A negative value represents the tributary daily maximum temperature being cooler than the corresponding mainstem Snake River.




Three Creeks
Difference (C)
0
-2
-4
-6
-8
-10
-12
-14
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Thermal Refugia
Max T Difference
Ave T Difference
Min T Difference
E
Kirkwood Creek
Difference (C)
0
-2
-4
-6
-8
-10
-12
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Thermal Refugia
Max T Difference
Ave T Difference
Min T Difference
F
Temperance Creek
Difference (C)
6
4
2
0
-2
-4
-6
-8
-10
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
Date
Thermal Refugia
Max T Difference
Ave T Difference
Min T Difference
G
Snake River
Hells Canyon Dam Tailrace
Maximum Daily Temperature
24
22
20
18
16
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12
10
5/1/2003
6/1/2003
7/1/2003
8/1/2003
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11/1/2003
Date
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IDAHO POWER
An IDACORP Company

Section 401 Water-Quality Certification Application

Hells Canyon Complex
FERC No. 1971

July 2016

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation/ Acronym	Definition
°C	degrees Celsius
7DAM	7-day average maximum
7Q10	10-year, 7-day discharge
A/C	air conditioning
AIR	additional information request
AME	absolute mean error
ATU	accumulated thermal unit
biocriteria	biological criteria
bkcal	billion kilocaleries
BL	baseline
BLM	United States Bureau of Land Management
BOD	biochemical oxygen demand
BSP	bacteria secondary production
CFD	computational fluid dynamic
CFR	Code of Federal Regulations
cfs	cubic feet per second
CFU	colony-forming units
cm	centimeters
COD	chemical oxygen demand
CWA	*Clean Water Act of 1972* (formerly known as the *Federal Water Pollution Control Act of 1948*, as amended)
DART	Data Access in Real Time
DBOD	dissolved biochemical oxygen demand
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DN	dissolved nitrogen
DO	dissolved oxygen
DOC	dissolved organic carbon
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
ESA	*Endangered Species Act of 1973*
ESPA	Eastern Snake Plain Aquifer
FEIS	final environmental impact statement
FERC	Federal Energy Regulatory Commission
FLA	final license application

Abbreviation/ Acronym	Definition
FPA	*Federal Power Act of 1935*, as amended
FPC	Federal Power Commission
FWS	United States Fish and Wildlife Service
g	grams
GBT	gas-bubble trauma
HAB	harmful algal bloom
HART	Oregon Hydroelectric Application Review Team
HCC	Hells Canyon Complex
HCD	Hells Canyon Dam
HCNRA	Hells Canyon National Recreation Area
HPS	hypolimnetic pumping system
HUC	hydrologic unit code
IDAPA	*Idaho Administrative Procedures Act*
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDHW	Idaho Department of Health and Welfare
IDWR	Idaho Department of Water Resources
IIHR	Iowa Institute of Hydraulic Research
IPC	Idaho Power Company
kg	kilogram
m	meter
m^2	square meter
m^3	cubic meter
m/s	meters per second
mg	milligram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
ml	milliliters
mm	millimeters
msl	mean sea level
MW	megawatt
MWMT	maximum weekly maximum temperature
NA	not available
NCC	Natural Conditions Criteria
ng/L	nanograms per liter
NHC	Northwest Hydraulic Consultants
NOAA	National Oceanic Atmospheric Administration

Abbreviation/ Acronym	**Definition**
NPDES	National Pollutant Discharge Elimination System
NSTP	natural seasonal thermal pattern
NTU	nephelometric turbidity units
O&M	operation and maintenance
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Health Authority
OP	orthophosphate
OPHD	Oregon Health Authority Public Health Division
OPUC	Public Utility Commission of Oregon
ORS	Oregon Revised Statute
OWRD	Oregon Water Resources Department
PAH	dimethylnaphthalene
PBOD	particulate biochemical oxygen demand
pH	hydrogen ion
PME	protection, mitigation, and enhancement
PMF	probable maximum flood
PNV	potential natural vegetation
POC	particulate organic carbon
PP	particulate phosphorus
PUSP	Provisional Unified State Position
RM	river mile
ROWQIP	Riverside Operation Water-Quality Improvement Project
RV	recreational vehicle
SCADA	Supervisory Control and Data Acquisition
SED	first-order sediment oxygen demand
SOD	sediment oxygen demand
SR–HC TMDL	Snake River–Hells Canyon Total Maximum Daily Load
SRPM	Snake River Planning Model
SRSP	Snake River Stewardship Program
SU	standard unit
SWDHD	Southwest District Health Department
SWG	Settlement Working Group
TAC	Technical Advisory Committee
TCS	temperature control structure
t-DDT	dichlorodiphenyltrichloroethane (total-DDT)

Abbreviation/ Acronym	**Definition**
TDG	total dissolved gas
TDS	total dissolved solids
TEMP	*Temperature Enhancement Management Plan*
TFT	The Freshwater Trust
TIC	total inorganic carbon
TL	total length
TMDL	total maximum daily load
TOC	total organic carbon
TOM	total organic matter
TP	total phosphorus
TSS	total suspended solids
TVA	Tennessee Valley Authority
µg/L	micrograms per liter
µm	micrometer
U.S.	United States
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USC	United States Code
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
VSS	volatile suspended solids
WMA	Wildlife Management Area
WMT	weekly maximum temperature
WQ	water quality

1. INTRODUCTION

Pursuant to the *Federal Power Act of 1935*, as amended (FPA), Idaho Power Company (IPC) filed an application with the Federal Energy Regulatory Commission (FERC) in July 2003 for a new license authorizing the continued operation and maintenance (O&M) of the Hells Canyon Complex (HCC), a 3-dam hydroelectric project comprised of the Brownlee Project, Oxbow Project, and Hells Canyon Project (collectively, FERC Project No. 1971-079). In the application, IPC proposed protection, mitigation, and enhancement (PME) measures to address effects associated with the HCC.

The HCC is located on the Snake River in Oregon and Idaho. Because the HCC is located on a border river between Oregon and Idaho, IPC is applying for *Clean Water Act of 1972* (CWA) § 401 certification from the Oregon Department of Environmental Quality (ODEQ) and Idaho Department of Environmental Quality (IDEQ) to certify any discharges originating in their respective states that may result from the continued operation of the HCC will comply with applicable water-quality standards. IPC is filing this as a joint application for Idaho and Oregon with the understanding that the ODEQ and IDEQ intend to coordinate their respective certification proceedings to avoid conflicts or inconsistencies in the issued certifications. Consistent with applicable law, each state's CWA § 401 certification will only include conditions relating to discharges within that state.

IPC first filed a CWA § 401 certification application (§ 401 application) with the ODEQ and IDEQ in July 2003. IPC has subsequently withdrawn and filed amended § 401 applications with both states in accordance with the requirements of CWA § 401. The latest application was filed in February 2015. With the February 2015 filing, IPC withdrew the May 2014 application and filed a new and revised § 401 application that included PME measures proposed to address dissolved oxygen (DO) and total dissolved gas (TDG) but not temperature. On May 22, 2015 IPC supplemented the February 2015 § 401 application to include Section 6.1. Temperature and Section 7.1. Temperature Proposed Measures, which evaluate temperature conditions and include PME measures proposed to address temperature. After discussion with the DEQs, IPC agreed to withdraw and resubmit a complete § 401 application on December 1, 2015.

1.1. HCC

1.1.1. Location Description

Hells Canyon is situated in west central Idaho and northeastern Oregon on the Snake River, a major tributary to the Columbia River and a border water of Oregon and Idaho. The HCC is in the southern part of Hells Canyon and forms 3 reservoirs: Brownlee, Oxbow, and Hells Canyon. A more detailed description of the HCC location is available in Exhibit A of the *New License Application: Hells Canyon Hydroelectric Complex*.

The FERC project boundary for the HCC extends from just above Porter Island (river mile [RM] 343), within Malheur County in the State of Oregon, approximately 5 miles northwest of Weiser, Idaho, to Hells Canyon Dam (HCD) (RM 247.6) in Wallowa County, Oregon (Figure 1.1-1). (Figure E.6-2, Panels 1–11, of the *New License Application: Hells Canyon*

Hydroelectric Complex, provides an area view at a larger scale.) The length of the project boundary extends just over 95 river miles. The width of the project boundary is typically several hundred feet and is generally defined as the distance between the average high-water lines on each bank of the reservoir. Exceptions to this typical width occur in the few specific areas where IPC owns larger areas of property. Notable exceptions are on the lower Burnt River, near the Spring Recreation Area; Sturgill Creek; Daly Creek and the upper end of the Powder River pool; and at the Brownlee and Oxbow operators' villages (Brownlee Village and Oxbow Village, respectively).

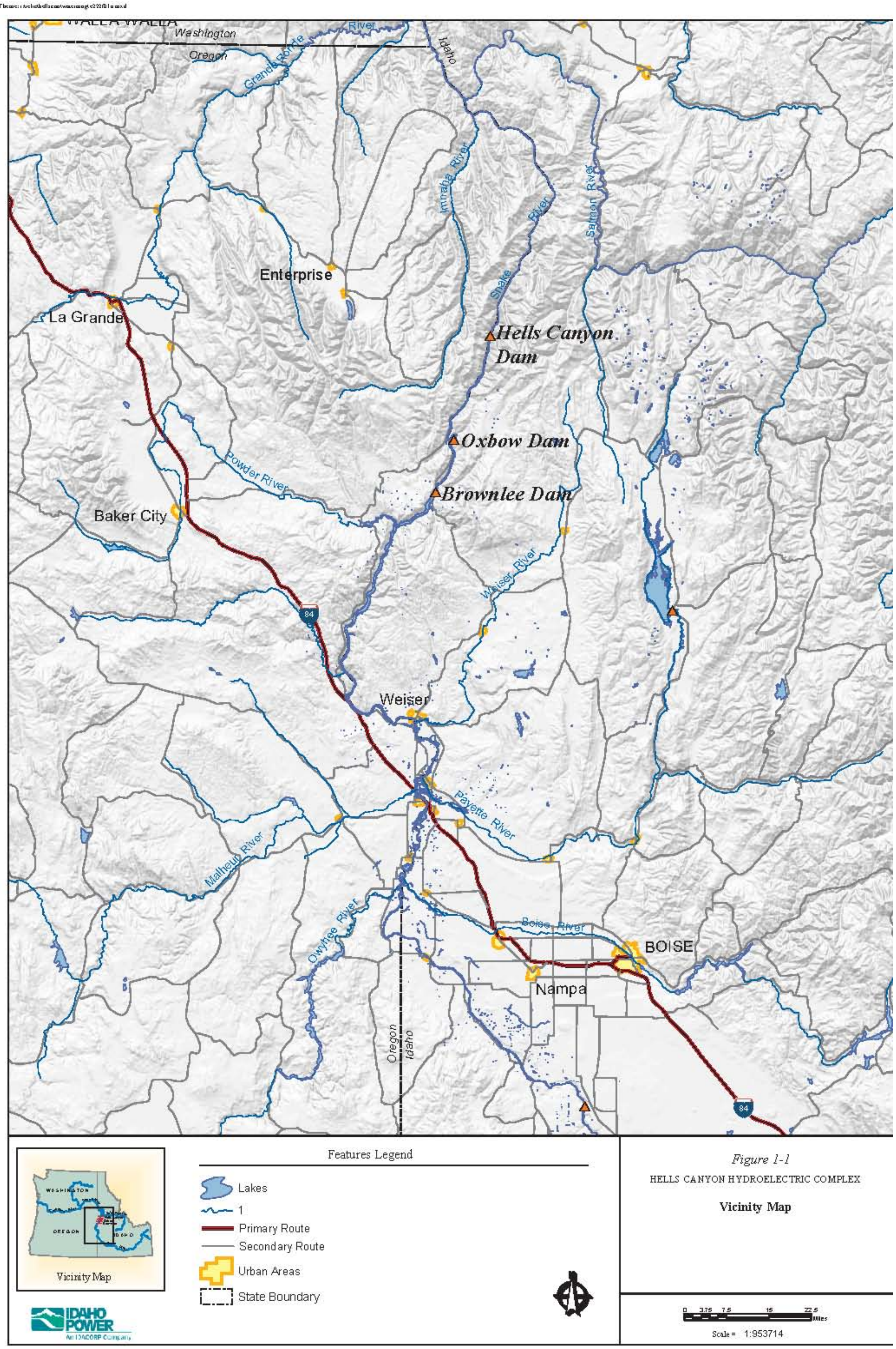

Figure 1.1-1
Vicinity map of IPC's HCC

The HCC is situated within and across the political boundaries of Malheur, Baker, and Wallowa counties in Oregon and Adams and Washington counties in Idaho; the HCC forms the border between these states. In Oregon, the upper approximately 10 miles of the project area (from just above Porter Island to the south side of Farewell Bend State Park) lie in Malheur County. Within this reach, approximately 10 islands in the Snake River lie entirely within Oregon. From the state park northward to approximately 12 miles below Oxbow Dam, the project area lies within Baker County. The remainder to the north (approximately 13 miles) is within Wallowa County and is also almost completely within the Wallowa–Whitman National Forest and the Hells Canyon National Recreation Area (HCNRA). The delineation between Adams and Washington counties in Idaho occurs near Brownlee Dam.

1.1.2. Construction History

IPC started access and site preparation work for Brownlee Dam on November 10, 1955. Brownlee Dam was substantially completed, and reservoir filling commenced on, May 9, 1958. Excavation for Oxbow Dam began on December 11, 1957. Oxbow Dam was completed, and reservoir filling commenced on March 12, 1961. Excavation for HCD began on August 27, 1964. HCD was completed, and reservoir filling commenced on, October 10, 1967.

The first Brownlee Project generating unit went into operation on August 27, 1958. The last Hells Canyon Project generator went into service on December 28, 1967. An additional turbine, Brownlee Project Unit No. 5, was constructed and placed in service on March 31, 1980. More details on project benchmarks and dates are available in Exhibit C of the *New License Application: Hells Canyon Hydroelectric Complex*.

1.1.3. Features of Interest

Prominent features of interest within the HCC in Oregon include Oxbow Dam and HCD. The Oxbow Village and Copperfield Park (RM 269.5) include the major developed areas for the HCC workforce. The village and park lie at the intersection of Oregon State Highway 86 (Oregon 86) and IPC’s road along Oxbow and Hells Canyon reservoirs. Approximately 20 residences, a kitchen and dining facility, bunkhouse, classroom facility, school, post office, and a 72-space park comprise the village. Approximately 0.25 to 0.5 miles upstream from Oxbow Village is the Oxbow shop complex (Oxbow Shop) and the Oxbow fish hatchery. The hatchery is an adult holding and spawning facility that has the capacity to produce 200,000 SRFC salmon (*Oncorhynchus tshawytscha*). Continuing upstream, shortly before reaching the bridge near Brownlee Dam (RM 283.9), the Brownlee Village and trailer park accommodate a smaller number of the HCC workforce (approximately 10 residences). The trailer park served as a camp during the construction of Brownlee Dam. A number of other United States (U.S.) Bureau of Land Management (BLM), state, and county recreation facilities; private residences; and recreational concessions are located in Oregon within the project boundary. These include a BLM facility at Copper Creek; private residences in the Homestead area; Hewitt and Holcomb parks (Baker County) on the Powder River arm (RM 7.5); a number of residences and cabins on the Powder River arm; residences in the Douglas Creek area; BLM’s Spring Recreation Area at the Burnt River (RM 326.7); the State of Oregon’s Farewell Bend State Park (RM 333.5); and the privately owned Snake River Recreational Vehicle (RV) and Oasis Campground, as well as the adjoining BLM Oasis site (RM 340).

On the Idaho side of the river, several additional points of interest are IPC's Brownlee Dam and power plant (RM 284.6), Woodhead Park (139 spaces) and the caretaker's house (RM 287.3), McCormick Park (34 spaces and tent camping) (RM 283.3), and Hells Canyon Park (24 spaces and tent camping) and the caretaker's house (RM 263.5). Other developments on the Idaho side not associated with IPC include the privately owned Mountain Man Lodge (RM 310.5); Steck Park (RM 327.9), cooperatively owned and run by the BLM and Idaho Department of Fish and Game (IDFG); and several private residences.

1.2. Existing License

1.2.1. Year Issued

The Federal Power Commission (FPC), predecessor agency to FERC, originally issued the license for the 3-dam hydroelectric project, known today as the HCC, on August 4, 1955. The license issued was for 50 years.

1.2.2. Year Expires

The original HCC license expired July 31, 2005. The project currently operates under an annual license.

1.3. New License Filing Schedule

1.3.1. Intent to File

A notice of intent to file a new license application for the HCC was filed by IPC in July 2000.

1.3.2. Draft License Application

IPC distributed a draft license application for the HCC to federal and state resource agencies, Indian tribes, and other interested parties in September 2002.

1.3.3. Final License Application

IPC filed a final license application (FLA) for the HCC with FERC on July 21, 2003 (*New License Application: Hells Canyon Hydroelectric Complex*).

1.3.4. Additional Information Request Filings

On May 4, 2004, IPC received additional information requests (AIR) from FERC relative to water-quality issues. More detail on operational scenarios is available in the *New License Application: Hells Canyon Hydroelectric Complex*, AIR OP 1; on DO augmentation in AIR WQ 1; and temperature control in AIRs WQ 2a, WQ 2b, and WQ 2c. The measures related to temperature control were reviewed by FERC in the 2007 *Final Environmental Impact Statement*

(FEIS)[1] in conjunction with a recommendation by several parties, including the Nez Perce and Umatilla tribes, that IPC investigate the installation of a temperature control structure (TCS) in Brownlee Reservoir to meet CWA numeric and narrative criteria to support downstream fisheries. FERC concluded the installation of a TCS was not warranted due to the high cost of the measure and the potential for adverse effects on Snake River fall Chinook (SRFC) salmon from increased temperatures during the summer migration season and the release of hypolimnetic water that is low in DO and high in concentrations of ammonia, mercury, and organochlorine compounds (FERC, 2007, p. 649–50).

2. CWA CERTIFICATION PROCESS

CWA § 401 (33 United States Code [USC] § 1341) requires that any person applying for a federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities that may result in any discharge into navigable waters, provides the licensing or permitting agency a certification from the state in which the discharge originates stating any such discharge will comply with applicable provisions of the CWA. FERC regulations require an applicant to also file with FERC a copy of the request for CWA § 401 certification pursuant to the U.S. Code of Federal Regulations (CFR) (18 CFR § 16.8(f)(7)).

The ODEQ is the agency of the State of Oregon designated to carry out the certification functions prescribed by CWA § 401 for Oregon waters. The IDEQ is the agency of the State of Idaho designated to carry out the certification functions prescribed by CWA § 401 for Idaho waters.

2.1. Oregon

The Oregon Environmental Quality Commission adopted Oregon Administrative Rules (OAR) 340-048-0005 through 340-048-0055 to prescribe the procedures for receiving, evaluating, and taking final action on a § 401 application. OAR 340-048-0020(2) identifies the information that must be included in an application for CWA § 401 certification.

In addition, Oregon Revised Statute (ORS) Chapter 543A prescribes procedures for coordination among state agencies regarding the reauthorization of federally licensed hydroelectric projects, including the state certification of water quality. The Oregon Hydroelectric Application Review Team (HART) is tasked with this responsibility, though the ODEQ has the lead responsibility on CWA § 401 certification.

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[1] A CD with a complete copy of the FEIS has been submitted to the ODEQ and IDEQ in conjunction with previous filings of the § 401 application.

2.2. Idaho

The Idaho Board of Environmental Quality has not adopted rules specific to the CWA § 401 certification process. However, the IDEQ has developed *Idaho Section 401 Certification Guidance* (IDEQ 2012) to foster a consistent statewide approach to CWA § 401 certification.

2.3. Other Potentially Applicable State Laws

CWA § 401 (d) requires any certification issued to set forth such limitations necessary to ensure compliance with applicable water-quality standards and "any other appropriate requirements of state law."[2] OAR 340-048-0020(j) requires a § 401 application filed with the ODEQ to identify and describe "other requirements of state law applicable to the activity that have any relationship to water quality." IPC provides the following in compliance with OAR 340-048-0020(j).

2.3.1. HART

ORS 543A establishes a HART process for developing a coordinated state position in governmental proceedings related to the reauthorization of existing hydroelectric projects. Oregon has initiated the HART process with regard to the FERC relicensing of the HCC, and IPC is participating in that process. Pursuant to ORS 543A, the HART process will include a reauthorization of IPC's water rights for the project and consideration of impacts to fish and wildlife habitat and resources; recreation; scenic and aesthetic values; historic, cultural, and archaeological sites; and botanical resources. HART for the HCC is composed of the following Oregon agencies: ODEQ; Oregon Department of Fish and Wildlife (ODFW); Public Utility Commission of Oregon (OPUC); Oregon Department of State Lands; Oregon Water Resources Department (OWRD); Department of Geology and Mining Industries; Oregon Marine Board; and the Oregon Parks and Recreation Department. The HCC HART issued a Provisional Unified State Position (PUSP) for the HCC licensing on April 25, 2003.

2.3.2. Laws Administered by the ODEQ and IDEQ

ORS 454.605, et seq., and OAR Chapter 340, Divisions 71 and 73, contain requirements to govern the on-site disposal of sewage. The purpose of such rules is to prevent health hazards and protect the quality of surface water and groundwater. The ODEQ contracts with local governments to administer the program pursuant to state rules.

IPC has received 2 permits for sewage disposal associated with the HCC. Permit number ID0020907 was originally issued, in part, for treated sanitary sewage at the Brownlee Project. This discharge was permanently eliminated on May 26, 2001, and replaced with a new, upland on-site disposal (septic) system permitted through the Idaho Department of Health and Welfare (IDHW), Southwest District Health Department (SWDHD). The ODEQ has permitted

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[2] 33 USC 1341(d). Because there are no federal requirements, such as effluent limitations or new source performance standards, applicable to hydroelectric projects, ODEQ certification conditions will be based solely on state law.

(OR-002727-8) a sewage holding tank for the Hells Canyon Project. As such, no treated or untreated sewage is disposed directly to surface waters of Oregon or Idaho.

IPC has 3 National Pollutant Discharge Elimination System (NPDES) permits issued for the disposal of non-contact cooling water and sump discharges: ID-002090-7, OR-002728-6, and OR-002727-8 at the Brownlee, Oxbow, and Hells Canyon projects, respectively. The constituents typically monitored and reported include flow rate, water temperature, oil and grease, hydrogen ion (pH), and total suspended solids (TSS).

Associated with the HCC, IPC maintains several comfort stations that include showers, restrooms and vault toilets, and RV dump stations (Table 2.3-1). IPC also contracts the placement of 30 portable toilets from April through October. In addition, there is a fish-cleaning station at Woodhead Park on Brownlee Reservoir. There is no treated or untreated wastewater discharged directly to surface waters of Oregon or Idaho. The largest facility, Woodhead Park, developed in 1994, disposes effluent by a land-application treatment system meeting IDEQ standards.

Table 2.3-1
Number of comfort stations (includes showers), restrooms and vault toilets, and RV dump-station treatment type by project in the HCC

Project	Location	Comfort Stations	Restrooms and Vault Toilets	RV Dump-Station Treatment Type
Brownlee	Woodhead Park	2	4	Wastewater treatment lagoon
Oxbow	McCormick Park	1	0	Drain field
	Carters Landing	0	1	Pump-out
	Oxbow Boat Launch	0	1	Pump-out
Hells Canyon	Copperfield Park	1	0	Drain field
	Hells Canyon Park	1	0	Drain field

IPC will improve and expand the recreational facilities in the HCC as part of the new license issuance. The McCormick Park comfort station will be replaced, increasing capacity, and another comfort station will be added at Hells Canyon Park. A camp host septic will be added at the Spring Recreation Site on Brownlee Reservoir, and IPC will rebuild the associated fish-cleaning station. Additionally, IPC will take over the maintenance of 18 vault toilets and add another 7 throughout the HCC.

2.4. IPC State Water Rights

IPC has vested rights to use the waters of the Snake River in connection with the Hells Canyon Project pursuant to water rights issued by Oregon and Idaho. The CWA does not supersede or abrogate rights to quantities of water that have been established by either state (CWA § 101(g), 33 USC § 1251(g)). By filing this application, IPC does not waive any vested state water rights.

2.4.1. Oregon Water Rights

IPC holds vested water rights in Oregon pursuant to the terms and conditions of Oregon License No. 189, issued April 22, 1968, for the period ending December 31, 2017. Similarly, under Oregon License No. 161, issued December 19, 1961, IPC has a vested right to use the waters of the Snake River in connection with the Oxbow Project, pursuant to the terms and conditions of such license, for the period ending December 31, 2015. Finally, under Oregon License No. 188, issued June 5, 1961, as amended January 20, 1981, IPC has a vested right to use the waters of the Snake River in connection with the Brownlee Project, pursuant to the terms and conditions of such license, for the period ending December 31, 2015. IPC requests the ODEQ include appropriate conditions in its certification that recognize and protect IPC's vested water rights under Oregon law.

2.4.2. Idaho Water Rights

IPC holds vested water rights in Idaho in connection with each of the 3 reservoirs that comprise the HCC. For Brownlee Reservoir, IPC has the following Idaho state water rights: 03-02018, 03-02023, 03-02024, and 03-07018. For Oxbow Reservoir, IPC has the following Idaho state water rights: 03-02019, 03-02025, and 03-10246. For Hells Canyon Reservoir, IPC has the following Idaho state water rights: 03-02017, 03-02020, 03-10184, and 03-10247.

3. CONCURRENT WATERSHED WATER-QUALITY PROCESSES

IPC supports the watershed approach used to develop and implement a total maximum daily load (TMDL) for the Snake River as an appropriate mechanism to improve the water quality of the Snake River and considers it particularly relevant to the CWA § 401 certification process. As such, IPC supported the development of the Upper Snake–Rock Creek TMDL (commonly referred to as the Middle Snake River TMDL), the King Hill–C. J. Strike Reservoir TMDL, the Middle Snake–Succor Creek TMDL, and the Snake River–Hells Canyon TMDL (SR–HC TMDL) and continues to actively participate in their implementation.

The SR–HC TMDL includes the reach of the Snake River associated with the HCC. The IDEQ and ODEQ issued the SR–HC TMDL in July 2003, with revisions in June 2004 (IDEQ and ODEQ 2004). The U.S. Environmental Protection Agency (EPA) approved the individual bacteria, pH, pesticides, and TDG TMDLs in March 2004 and the rest of the TMDLs in September 2004.[3]

[3] On October 7, 2003, IPC filed a petition for judicial review in the Circuit Court for Baker County, Oregon, Case No. 03-678, challenging those portions of the SR–HC TMDL that impose a temperature load allocation on the HCC. This petition is still pending; it has been extended annually by agreement between IPC and the State of Oregon and approval of the court. This notwithstanding, IPC will propose PME measures as part of the § 401 application process that address temperature effects of the HCC downstream of HCD.

3.1. A Watershed-Based Approach

CWA § 303 requires that states adopt water-quality standards necessary to protect designated beneficial uses, including fish, wildlife, and recreation. Subsection 303(d) establishes requirements for states to identify and prioritize water bodies that are water-quality limited or impaired (i.e., water bodies that do not meet applicable water-quality standards). Oregon and Idaho's *Integrated Report* lists these waters, as well as the current condition of all state waters (CWA § 305(b)). For waters identified in Category 5 of the *Integrated Report*, states must develop a TMDL for each of the pollutants for which water-quality standards are exceeded.

TMDLs define the amount of a particular pollutant that can be present in a water body without causing an exceedance of applicable water-quality standards or non-attainment of beneficial uses. TMDLs also define, based on the best available science, the amount of a pollutant a water body can receive from all sources and still meet applicable water-quality standards. Natural sources of pollutants, as well as releases from point and nonpoint sources (anthropogenic sources), are taken into consideration in the development of TMDLs. Pollutant loads are then allocated or budgeted to the identified sources (including natural sources) in a manner that describes the total amount of pollutant load that can be released to the water body by each identified source without causing applicable water-quality standards to be exceeded. In this way, the IDEQ and ODEQ (2004) stated, "responsibility for improving water quality lies on the shoulders of everyone who lives, works or plays in a watershed that drains into an impaired waterbody."[4] A key objective of the TMDL process was to "establish load allocation mechanisms that will allow attainment of the water quality targets through (to the extent possible) fair and equitable distribution of the identified pollutant loads, and result in productive implementation without causing undue hardship on any single pollutant source."[5]

In connection with the development of TMDLs, water-quality management plans (referred to as implementation plans in Idaho) are also developed to identify actions to achieve the TMDL load and waste load allocations and improve the water quality of a listed water body. In Oregon, these management plans must be submitted to the EPA with a draft TMDL for approval. In Idaho, implementation plans are to be developed within 18 months of the EPA's approval of the TMDL. The implementation of these management plans, which generally includes periodic reviews and revisions, is expected to result in the attainment of water-quality standards for a CWA § 303(d) listed water body.

3.2. Development of TMDLs in the Watershed

Segments of the Snake River, upstream and downstream of the HCC, are listed by Oregon and Idaho as water-quality limited under § 303(d) of the CWA. Information on the segments listed and the water-quality standards exceeded can be accessed on the ODEQ and IDEQ websites.

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[4] SR–HC TMDL, p. 4.

[5] SR–HC TMDL, p. 18.

Consistent with these listings, TMDL processes and related management plans are in place or are being developed for most of the upstream waterways, including the Weiser, Payette, Malheur, Owyhee, and Boise watersheds, as well as the Snake River upstream through American Falls Reservoir. The Snake River TMDLs include the Middle Snake–Succor Creek, King Hill–C. J. Strike Reservoir, Middle Snake, Upper Snake–Rock Creek, Lake Walcott, and American Falls. The management or implementation plans associated with these TMDL efforts contain mechanisms specifically targeted to reduce, among other pollutants, bacteria, sediment, nutrients, DO, and temperature impacts to tributary watersheds and the Snake River. In many cases, implementation plans have already begun upstream and are demonstrating positive results. While the ODEQ and IDEQ expect that water quality in the Snake River will improve with the implementation of the TMDLs and that these improvements will lead to corresponding water-quality benefits in the HCC, the agencies also note that, due to the size of the watershed and the complexities involved, an extended period of time will be required to achieve the water-quality targets (IDEQ and ODEQ 2004). According to the SR–HC TMDL:

> For watersheds that have a combination of point and nonpoint sources where pollution reduction goals can only be achieved by including some nonpoint source reduction, a reasonable assurance that reductions will be met must be incorporated into the TMDL (EPA, 1991). The SR–HC TMDL will rely on nonpoint source reductions to meet the load allocations to achieve desired water quality and to restore designated beneficial uses. The State of Oregon Water Quality Management Plan and the State of Idaho Implementation Plan (Section 6.0) contain more detailed information on implementation programs that will provide reasonable assurance of implementation.[6]

For purposes of this application, reasonable assurance of compliance with the water-quality standards assumes full implementation of TMDLs.

3.3. The SR–HC TMDL

In addition to the TMDL processes referenced previously, the ODEQ and IDEQ initiated a TMDL process in 2000 involving the reach of the Snake River associated with the HCC. This process was in response to CWA § 303(d) listings by Oregon or Idaho for bacteria, sediment, pesticides, DO, nutrients, pH, temperature, and mercury. Additionally, TDG was assessed during the TMDL process, and Idaho added TDG and removed bacteria and pH as pollutants impairing reaches of the Snake River and the HCC. The SR–HC TMDL and *Water Quality Management Plan* were issued by the IDEQ and ODEQ in July 2003 and revised in June 2004. The EPA approved pesticide and TDG TMDLs in March 2004 and nutrients, sediment, DO, and temperature TMDLs in September 2004. The SR–HC TMDL covers the mainstem Snake River from RM 409 near the town of Adrian, Oregon, to the inflow of the Salmon River at RM 188.2 and includes Brownlee, Oxbow, and Hells Canyon reservoirs.

[6] SR–HC TMDL, p. 475.

The EPA added chlorophyll *a* in 2012 to Oregon's CWA § 303(d) list as impairing reaches of the Snake River and the HCC outside of the irrigation season.

IPC actively participated in the SR–HC TMDL process as part of a larger watershed water-quality approach initiated by the ODEQ and IDEQ because improvement in water quality in the Snake River depends on water-quality improvements throughout the Snake River watershed. Water quality within the HCC reservoirs, as well as the water quality of releases from those reservoirs, is largely a function of the quality of the Snake River water flowing into Brownlee Reservoir. The ODEQ and IDEQ also recognize the interrelationship of the TMDL efforts on the Snake River with the HCC licensing and CWA § 401 certification processes (IDEQ and ODEQ 2004).

The IDEQ and ODEQ (2004) describe the available database on water-quality conditions in the lower Snake River and Hells Canyon reaches of the Snake River as "robust" (much of the data being the result of the IPC's study and data-collection efforts associated with the licensing of the HCC). However, the states recognize that achieving water-quality standards in a river as complex as the Snake River would require an iterative and extended process that will require several decades to respond completely to implementation projects and changes in management. The SR–HC TMDL specifically notes the following:

> As demonstrated by the size and diversity of the issues addressed in this document, the SR–HC TMDL reach is a highly complex system and will no doubt yield unexpected results as implementation and further data collections proceeds. The challenges encountered in determining designated beneficial use support and system impairment are an outgrowth of this complexity and will require additional assessment and revisitation as our understanding of the system evolves. Additionally, due to the complexity encountered and the enormous geographic scope of the effort, an extended time period for implementation and system response will be required.[7]

With regard to temperature specifically, the SR–HC TMDL states it is difficult to determine what natural temperature conditions are for such a highly regulated system or precisely how altered current conditions are from natural conditions (IDEQ and ODEQ 2004). To address this, it suggested a site-potential analysis in part to assess the influence of the HCC on water temperatures downstream and develop a temperature load allocation for the project using inflow temperatures measured at Brownlee Reservoir as an estimate of site potential in the Snake River downstream of the HCC.

IPC disagreed with the site-potential standard because it allows upstream temperatures to exceed the applicable numeric temperature criterion. The site-potential standard effectively supersedes the upstream numeric criterion of 19 degrees Celsius (°C) (previously 17.8°C at the time of the SR–HC TMDL), even though the SR–HC TMDL determined elevated temperatures upstream of the HCC are due in part to anthropogenic sources, such as upstream and tributary impoundments,

[7] SR–HC TMDL, p. 481–482.

water withdrawals, channel straightening and diking, and the removal of streamside vegetation that cannot be precisely quantified. This is not consistent with the ODEQ's definition of "natural conditions" for purposes of applying the ODEQ's Natural Conditions Criteria (NCC). See OAR 340-041-0002(41) and 340-041-0028(8). While the TMDL provided that this estimate of site potential should not be interpreted as natural conditions, the elevated site-potential temperatures supplant the applicable numeric criteria upstream of the HCC.[8] IPC generally concurred that natural-condition temperatures for the Snake River prior to Euro-American settlement could not be precisely determined. However, during the public comment period to the 2001 draft SR–HC TMDL, IPC asserted that the SR–HC TMDL temperature analysis improperly ignored upstream anthropogenic effects on water temperature (IPC 2002).

Despite that assertion, IPC considered the IDEQ's and ODEQ's 2001 approach to temperature in the draft TMDL to be acceptable because "…it has treated all anthropogenic temperature influences in the watershed equally and has not attempted to make-up for the ignored effects of these influences by allocating additional, disproportional load allocations to specific anthropogenic influences, including the HCC."[9] IPC also commented that the manner in which the IDEQ and ODEQ addressed temperature in the SR–HC TMDL was consistent with prior TMDLs developed in Idaho:

> The manner in which the DEQs approach the temperature issue in this Draft TMDL is similar to the approach used by IDEQ in the Payette watershed. In the EPA approved Payette TMDL, IDEQ acknowledged that while water temperatures in the watershed exceeded water quality standards for cold water biota and salmonid spawning (as in the Snake River), other factors, including habitat modification and flow alteration, were significant causes of beneficial use impairment. IDEQ further found that another condition that precluded the development of a temperature TMDL in the Payette watershed was warm water temperatures upstream of Black Canyon Reservoir. IDEQ therefore concluded in the Payette TMDL "because of these conditions, it is recommended that temperature TMDL not be developed due to external sources of warm water temperatures and habitat modification." IPC recommends that the current approach in this Draft TMDL be maintained, as it is consistent with IDEQ's prior practice and is otherwise fundamentally fair.

The EPA also submitted comments to the 2001 draft SR–HC TMDL. In those comments, the EPA expressed concern that increased fall temperatures below the HCC should be considered in the temperature TMDL because "the fall period in question includes one of the most critical time periods for SRFC, which spawn below HCD. Allocations should be established to ensure

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[8] While the concept of site potential may not be representative of natural conditions, it may suffer from the same legal infirmities of the Oregon NCC that was struck down by the Court in *Northwest Environmental Advocates v. EPA et al.*, 855 F.Supp.2d 1199 (D. Or. 2012) (*NWEA II*).
The EPA subsequently withdrew its approval of Oregon's NCC for temperature by letter to the ODEQ dated August 8, 2013.

[9] IPC letter to Tonya Dombrowski (IDEQ) dated April 19, 2002.

temperature criteria are attained during the spawning and incubation periods."[10] IPC also addressed the fall spawning period in its 2002 comments:

> Fall Chinook spawning downstream of Hells Canyon Dam is currently supported under the existing thermal regime… Nonetheless fall Chinook spawning water temperature criteria (13°C and 9°C), as currently established, are difficult to meet below the HCC because the temperature of water flowing into the HCC is well above the temperature criteria. However, reservoir temperature modeling shows that when upstream inflow temperatures meet the applicable target, downstream temperatures are at or near criteria…These results demonstrate that a broad watershed based approach is needed to address temperature problems in the Snake River.[11]

On July 15, 2003, the ODEQ and IDEQ issued the final SR–HC TMDL that imposed a temperature load allocation[12] for the outflow from HCD of no greater than a maximum weekly maximum temperature (MWMT) of 13°C when inflow temperature to Brownlee Reservoir, defined as site potential in the SR–HC TMDL, is less than an MWMT of 13°C or no more than a 0.14°C increase in water temperature when site potential is greater than an MWMT of 13°C.[13] The load allocation applies from October 23 through April 15 for SRFC spawning and November 1 through March 30 for mountain whitefish (*Prosopium williamsoni*) spawning.

4. PROJECT DESCRIPTION

4.1. Legal Name and Address of Project Owner

Idaho Power Company
1221 W. Idaho St.
P.O. Box 70
Boise, ID 83702
Phone: 208-388-2676

[10] EPA letter to the IDEQ and ODEQ, dated April 24, 2002. In its comments, the EPA also acknowledged that in making determinations regarding natural conditions, "temperatures at the upstream boundary of the TMDL are used as the baseline for the natural condition."

[11] IPC public comments on the draft SR–HC TMDL, April 19, 2002, at p. 7.

[12] Waste load allocations, specific to the 3 NPDES permits issued for the Brownlee, Oxbow, and Hells Canyon powerhouses were also assigned in the SR–HC TMDL.

[13] Oregon has revised standards for allowable anthropogenic increases to 0.3°C. This revision affects IPC's load allocation.

4.2. Legal Name and Address of Owner's Official Representative

James C. Tucker
Lead Counsel
Idaho Power Company
1221 W. Idaho St.
P.O. Box 70
Boise, ID 83702

4.3. Adjacent Lands

4.3.1. Names and Addresses of Contiguous Property Owners

Names and addresses of Oregon contiguous property owners to the HCC are included as Exhibit 4.3-1.

4.3.2. Adjacent Land Use

The project area includes 17,070 acres of land, including lands above and below the normal high-water mark (Table 4.3-1)[14]. Of the total project acreage, 5,600 acres (33%) are federally owned; 340 acres (2%) are state owned; and 11,130 acres (65%) are privately owned. Of the privately owned land in the project area, IPC owns 9,660 acres (57% of the total acreage).

Table 4.3-1
Land ownership (acres) in the HCC project area

Land Ownership	Hells Canyon	Oxbow	Brownlee	Total HCC	% of Total
Total Lands (flooded and non-flooded lands)					
Federal lands					
U.S. Forest Service (USFS)	1,360	–	–	1,360	7.97
BLM	240	570	3,430	4,240	24.84
Total federal lands	*1,600*	*570*	*3,430*	*5,600*	*32.81*
State lands	0	10	330	340	1.99
IPC lands					
Limited-use rights	30	0	1,140	1,170	6.85
Full-use rights	330	1,100	7,060	8,490	49.74
Total IPC lands	*360*	*1,100*	*8,200*	*9,660*	*56.59*
Other private lands	100	610	760	1,470	8.61
Total acreage in project boundary	**2,060**	**2,290**	**12,720**	**17,070**	**100.00**

[14] IPC has proposed a new project boundary as part of the HCC new license application. Table 4.3-1 is based on the existing project boundary.

Table 4.3-1 (continued)

Land Ownership	Hells Canyon	Oxbow	Brownlee	Total HCC	% of Total
Flooded Lands					
Federal lands					
USFS	970	–	–	970	9.49
BLM	220	300	2,180	2,700	26.42
Total federal lands	*1,190*	*300*	*2,180*	*3,670*	*35.91*
State lands	0	0	110	110	1.08
IPC lands	90	120	6,000	6,210	60.76
Other private lands	0	80	150	230	2.25
Total acreage flooded	**1,280**	**500**	**8,440**	**10,220**	**100.00**

Of the total project acreage, 6,850 acres (40%) are above the normal high-water mark. (These acreages are determined by subtracting the flooded lands from the total land values.) Federal and state lands comprise 1,930 acres (28%) and 230 acres (3%), respectively, of the total unflooded acreage. Private lands make up 4,690 acres (68%) of the unflooded lands in the project area. Of these lands, IPC owns 3,450 acres, or half of all unflooded lands in the project area.

At the upstream end of the project area near Weiser, Idaho, agriculture and private ownership are extensive. As the canyon steepens along Brownlee Reservoir, more lands come under federal ownership, primarily managed by the BLM. Significant state ownership associated with the Cecil D. Andrus Wildlife Management Area (WMA) occurs on the Idaho side, just upstream of Brownlee Dam. On the Powder River arm, BLM and private lands are interspersed until agriculture and corresponding private ownership predominate around Richland, Oregon.

Along Oxbow Reservoir, BLM-managed land and private lands continue to be intermixed. IPC’s land ownership in fee is focused on Brownlee and Oxbow reservoirs, with several larger parcels on the Powder River arm of Brownlee Reservoir.

On the Idaho side, the Payette National Forest reaches down to Hells Canyon Reservoir just downstream of Oxbow Village and continues on to HCD, where the HCNRA begins. Private ownership predominates the Oregon side of Hells Canyon Reservoir, with a few larger parcels of BLM-managed lands interspersed down to Copper Creek, which forms the boundary of the HCNRA and wilderness area.

Land in the HCC is used for 6 primary purposes: 1) cultivated agriculture, 2) livestock grazing, 3) hydroelectric power generation, 4) recreation, 5) wildlife habitat, and 6) residential and rural residential use. In the past, industrial mining and timber harvest also occurred. Any mining remaining in the area is believed to be recreational rather than industrial. Although timber sales and harvest may still occur at higher elevations, no harvest is known to have recently occurred. Interstate 84 (I 84) passes near the upper end of the project area on the Oregon side. A small area of commercial use occurs adjacent to I 84 at Farewell Bend, Oregon. The distribution of these land uses and the aesthetic character of the area are largely determined by the canyon’s geography. More detail on land use throughout the HCC is available in Exhibit E.6 of the *New License Application: Hells Canyon Hydroelectric Complex*.

4.3.3. Evaluation of Consistency of IPC's Project with County Comprehensive Plans

Per Oregon regulations OAR 340-048-0020(2)(i)(A) and (C), an applicant must provide an exhibit that "includes land use compatibility findings for the activity prepared by the local planning jurisdiction" and "discuss the potential direct and indirect relationship to water quality of each finding or land use provision." The HCC is within, or adjacent to, Malheur, Baker, and Wallowa counties in Oregon. Although the FPA may preempt county plans, IPC provides, as Exhibit 4.3-2 to this application, the findings and an evaluation of such plans in accordance with the Oregon regulations.

More detail is available in the *New License Application: Hells Canyon Hydroelectric Complex*. Proposed PME measures are included in Section E.6.4., and the *Hells Canyon Resource Management Plan* is included as Technical Report E.6-1., also summarized in Section E.6.4 of Exhibit E.

4.4. Project Overview

The HCC includes the Snake River from Farewell Bend, Oregon, downstream approximately 95 river miles to HCD. The HCC is comprised of Brownlee, Oxbow, and HCDs and reservoirs. The reservoirs were constructed primarily for power production, although Brownlee Reservoir has operational requirements related to flood control. The 3-dam complex was initiated in 1958 with the construction of Brownlee Dam. The contemporary Oxbow Project was constructed in 1961, and HCD was constructed in 1967. Together, the 3 hydroelectric projects have a total nameplate generating capacity of 1,166.9 megawatts (MW), or enough electric energy to supply 758,485 homes. As such, the HCC is the centerpiece of IPC's generating portfolio and is critical to the economies of Idaho and eastern Oregon. More detail on IPC's hydroelectric resources is available in Exhibit H of the *New License Application: Hells Canyon Hydroelectric Complex*.

The combined water volume of the 3 HCC reservoirs is approximately 1,647,500 acre-feet, while the usable storage is 1,009,198 acre-feet. All of the reservoirs can be characterized as relatively deep, with mean depths ranging from 50 feet (Oxbow Reservoir) to 100 feet (Brownlee Reservoir). The maximum depth in Brownlee Reservoir is 300 feet. More detail on the physical characteristics of the HCC reservoirs is available in Technical Report E.2.2-2 of the *New License Application: Hells Canyon Hydroelectric Complex*. Both Oxbow and Hells Canyon reservoirs have normal water-level fluctuations of approximately 5 feet, with an additional 5 feet for atypical circumstances. In contrast, the water-level fluctuation of Brownlee Reservoir is approximately 100 feet. Most water-level fluctuation in Oxbow and Hells Canyon reservoirs is related to power production, while flood control accounts for most of the annual change in water-surface elevation in Brownlee Reservoir.

Brownlee Reservoir is the largest of the 3 reservoirs, with a total volume of approximately 1,420,000 acre-feet and a usable storage of 975,318 acre-feet. The average annual flow into Brownlee Reservoir is approximately 13,000,000 acre-feet. Despite the large volume of

Brownlee Reservoir, retention times are relatively low (approximately 30 days) because of the large amount of flow into the reservoir.

Snowmelt runoff dominates the project area's hydrology. Based on records of U.S. Geological Survey (USGS) gage 13269000, Brownlee Reservoir receives its highest inflows in May (Brennan et al. 2000). The lowest rate of inflow occurs in August when precipitation levels are lowest and irrigation diversions in the Snake River are highest (USBR 1999). This general hydrologic regime is typical of most major tributaries to the HCC. However, this regime probably does not reflect the natural hydrologic processes because many of the tributaries are regulated by reservoirs for flood control, agricultural water supplies, power generation, and recreation (IDWR 1971). Many of the drains discharge small volumes of water (less than 1 cubic meter [m^3] per second) from irrigated cropland adjacent to the Snake River (Myers et al. 1998).

The use of Brownlee Reservoir to meet flood-control requirements may result in slightly higher flows from January through April and slightly lower flows in May and June than would occur without the flood-control requirements. Because Oxbow Reservoir receives flows primarily from Brownlee Reservoir, and Hells Canyon Reservoir, in turn, receives discharged flows primarily from Oxbow Reservoir, the hydrologic regimes of Oxbow and Hells Canyon reservoirs are very similar to that of Brownlee Reservoir.

4.5. Project Operations

The HCC includes the dams, reservoirs, and power plants associated with the Brownlee, Oxbow, and Hells Canyon projects. Operations of the 3 projects of the HCC are closely coordinated to generate electricity and serve many other public purposes.

Currently, 471,779 customers rely on IPC's hydroelectric and thermal generation system for power. The HCC is a critical part of IPC's generation system. Its winter and summer operations are particularly important because energy needs are highest during those seasons. In winter, customers need extra electricity for lighting and heating. During the summer, they need extra electricity for air conditioning (A/C) and irrigation pumping.

IPC operates the HCC to comply with its existing FERC license, as well as voluntary arrangements to accommodate other interests, such as recreational use and environmental resources. Among these arrangements are the *Fall Chinook Interim Recovery Plan and Study* (IPC 1991), voluntarily adopted by IPC in 1991 to protect the spawning and incubation of SRFC salmon below HCD, which are listed as a threatened species under the *Endangered Species Act of 1973* (ESA), and, most recently, the *Hells Canyon Hydroelectric Project Settlement Process Interim Agreement* (Interim Agreement) IPC entered into with multiple parties relating to the operation of the HCC pending the issuance of a new license. While portions of the Interim Agreement have expired, other portions remain in effect pending the issuance of a new license for the HCC.

4.5.1. Brownlee Reservoir Operations

Brownlee Reservoir is 1 of the 3 HCC developments and is IPC's only project with significant storage. It has 101 vertical feet of active storage capacity that equals approximately 1 million acre-feet of water. Brownlee Dam's hydraulic capacity is also the largest of the 3 HCC developments. Its powerhouse capacity is approximately 35,000 cubic feet per second (cfs).

Brownlee Reservoir is a multiple-use, year-round resource for the Northwest. Although its primary purpose is to provide a stable power source, Brownlee Reservoir is also used for flood control, fish and wildlife mitigation, and recreation. Brownlee Dam is one of several northwest dams that cooperate to provide spring flood control on the lower Columbia River.

For flood control, IPC operates the reservoir cooperatively with the U.S. Army Corps of Engineers (USACE) North Pacific Division. After flood-control requirements have been met in early summer, the reservoir is refilled to meet peak summer electricity demands and provide suitable habitat for spawning bass (*Micropterus* spp.) and crappie (*Pomoxis* spp.). The full reservoir also offers optimal recreational opportunities through the Fourth of July holiday.

The U.S. Bureau of Reclamation (USBR) periodically releases water from its storage reservoirs in the Snake River watershed to assist with the migration of anadromous fish, species that ascend rivers from oceans to spawn, past the lower Snake River Federal Columbia River Power System projects, established as a reasonable and prudent alternative by the Federal Columbia River Power System biological opinion. As part of the Interim Agreement among multiple parties filed with FERC in January 2005, IPC agreed to provide up to 237,000 acre-feet of water from Brownlee Reservoir in June and July 2005 and 2006, provided such operation did not cost more than $2 million annually or jeopardize the reliability of the electric system. Although the portion of the Interim Agreement relating to annual flow augmentation releases has expired, in cooperation with the National Oceanic and Atmospheric Administration (NOAA) Fisheries, IPC has continued to provide these flow augmentation releases annually through 2014. FERC staff included a recommendation for the continuance of these flow augmentation releases from the HCC in the FEIS issued in August 2007 (FERC 2007). IPC expects to continue discussions with the federal resource agencies with regard to annual flow augmentation releases pending the relicensing of the HCC.

In late fall, Brownlee Reservoir's releases are managed to maintain constant flows below HCD. These flow requirements, which are based on the *Fall Chinook Interim Recovery Plan and Study* (IPC 1991), as well as the minimum flow required by Article 43 of the existing license, help ensure sufficient water levels to protect even the shallowest spawning nests, or redds. After SRFC salmon spawn, IPC attempts to have a full reservoir by the first week of December to meet winter peak demands.

4.5.1.1. Winter—December through February

Electricity demands are critical during the winter in IPC's service area and throughout the Northwest. To meet peak winter demands and maintain system reliability, the water level in Brownlee Reservoir should be at an elevation of 2,075 feet mean sea level (msl) by the first week in December. If the reservoir is filled to that level, the system can provide stable, reliable energy through the winter and reduce operating costs by minimizing the need for purchasing outside power.

During December through February, IPC maintains minimum flows below HCD to ensure sufficient water levels for SRFC salmon redds. By January or February, IPC begins to draft the reservoir to meet elevation targets for flood control.

4.5.1.2. Spring—March through May

The USACE North Pacific Division defines flood-control requirements and coordinates flood-control efforts with IPC. During the spring, IPC complies with Article 42 of the existing license and responds to the USACE's request to lower the water level in Brownlee Reservoir. The lower water level provides space for excess spring runoff and helps prevent flooding, primarily on the lower Columbia and Snake rivers.

IPC's existing license requires the reservoir's elevation to be at or below 2,034 feet msl by March 1, a level that provides approximately 500,000 acre-feet of storage space for flood control. The license also stipulates that the USACE may request an additional 500,000 acre-feet of storage space if necessary. However, in past years when snowpack was less than normal, the USACE reduced the storage space requirement.

In the mid-1980s, the USACE examined the reservoir's flood-control operations and developed a rule curve table for Brownlee Reservoir's target elevations. These target elevations define the space in the reservoir needed for flood control and are based on forecasted runoff at both the Brownlee and The Dalles (Oregon) projects. More recently, the rule curve procedure was improved. This new rule curve provides a more gradual change in reservoir elevations to reach required storage volumes by targeted dates.

IPC initiated the new rule curve for water year 2000 flood-control requirements. Depending on the water year and USACE mandates, flood-control requirements for Brownlee Reservoir may continue through June. To meet mandated target elevations for flood control, IPC may need to spill water through the HCC. Although there are no official refill target elevations, the USACE controls how quickly the reservoir can be refilled once flood-control requirements are met.

4.5.1.3. Summer—June through August

After IPC is released from flood-control responsibilities, the company begins refilling Brownlee Reservoir. The refill target is 2,069 feet msl (approximately 8 feet below the full reservoir capacity of 2,077 feet msl) toward the end of May and full by the end of June. Meeting these targets ensures enough water is stored in Brownlee Reservoir to meet peak summer electricity demands, provide suitable spawning habitat for bass and crappie, and offer optimal recreational opportunities.

To cooperate with federal efforts to meet flow objectives at Lower Granite Dam established by the Federal Columbia River Power System biological opinion, in the past IPC has provided flow augmentation releases from Brownlee Reservoir. IPC will continue to provide flow augmentation releases pursuant to an Interim Agreement among multiple parties filed with FERC in January 2005. The relevant portions of that agreement provide that IPC will draft Brownlee Reservoir in June and July to an elevation of 2,059 feet msl, which, if the reservoir is full at the beginning of the draft, will result in the release of up to 237,000 acre-feet of water, provided such operation does not cost more than $2 million annually or jeopardize the reliability of the electric system. Although the portion of the Interim Agreement relating to annual flow augmentation releases has expired, IPC has continued to provide these flow augmentation releases in cooperation with NOAA Fisheries annually through 2014. FERC staff included a recommendation for flow augmentation releases from the HCC in the FEIS issued in August 2007 (FERC 2007).

4.5.1.4. Fall—September through November

During the fall, Brownlee Reservoir is largely operated to benefit SRFC salmon below the HCC. After the delivery of flow augmentation water, Brownlee Reservoir releases are managed to maintain a constant flow below HCD to provide stable conditions for spawning SRFC salmon. The spawning flow is based on a minimum reservoir elevation of approximately 2,040 feet msl when the program starts in October and forecasted inflows so that Brownlee Reservoir is full, around 2,075 feet msl, by the first week in December. The minimum flow below HCD is maintained through fry emergence in the spring and established by maintaining water over the shallow-most redd (IPC 1991). Once this flow is set, it is considered the minimum flow necessary to keep embryos from desiccating until they emerge as fry in the spring (i.e., the spawning flow is maintained as a minimum flow until emergence is complete). Maintenance of these flows often results in a lowering of the reservoir elevation in Brownlee Reservoir, which affects the power production capability of the Brownlee Power Plant. Therefore, implementation of the *Fall Chinook Interim Recovery Plan and Study* may require IPC to purchase power from other sources if the load demand cannot be met due to the loss in net head at the reservoir.

4.5.2. Oxbow Reservoir and Hells Canyon Reservoir Operations

Target elevations for Brownlee Reservoir define the flow of water and, therefore, operations through Oxbow and Hells Canyon reservoirs. Oxbow and Hells Canyon reservoirs have much smaller active storage capacities, approximately 0.5 and 1.0%, respectively, of Brownlee Reservoir's volume, with slightly smaller hydraulic capacities of 28,000 and 30,500 cfs, respectively.

When flows through the HCC are below hydraulic capacity, all 3 projects operate closely together to reregulate flows through the Oxbow and Hells Canyon projects so they remain within the 1-foot-per-hour ramp-rate requirement (measured at Johnson Bar below HCD) and meet the daily peak-load demands. However, when flows exceed the powerhouse capacity for any of the projects, water is released over the spillways at those projects.

In addition to maintaining the ramp rate, IPC maintains minimum flow rates in the Snake River downstream of HCD. These minimum flow rates are for navigation purposes as specified under Article 43 of the existing license. Neither the Brownlee Project nor the Oxbow Project has a minimum flow requirement below its powerhouse. However, because of the Oxbow Project's unique configuration, a flow of 100 cfs is maintained through the bypassed reach of the Snake River below the dam (a segment called the Oxbow Bypass).

5. Applicable Water-Quality Regulations

5.1. Beneficial Uses

As border water, the Snake River has designated uses established by both Oregon and Idaho. The ODEQ has designated fish and aquatic life, recreation, water supply, wildlife habitats, aesthetics, commercial navigation and transportation, and hydro power uses for the mainstem Snake River (Table 5.1-1). The IDEQ has designated similar uses (Table 5.1-2). In addition, the ODEQ has specified anadromous fish migration corridors, and salmon and steelhead (*Oncorhynchus mykiss*) spawning are designated uses downstream of HCD to the Washington border. Redband trout (*Oncorhynchus mykiss gairdnerii*) rearing is a designated use in the HCC upstream to the Idaho border.

Table 5.1-1
Oregon's designated uses (OAR 340-041 n.d.) and water-quality limiting pollutants (ODEQ 2014) for the mainstem Snake River

Snake River Segment	Designated Uses	Pollutants
Snake River: Washington border to HCD	Salmon and steelhead spawning Anadromous fish migration corridors Resident fish and aquatic life Water contact recreation Public/private domestic water supply Irrigation Livestock watering Industrial water supply Wildlife and hunting Fishing and boating Aesthetics Commercial navigation and transportation Hydro power	Temperature[1] Toxics (mercury)
Snake River: HCD to Idaho Border	Redband trout rearing Resident fish and aquatic life Water contact recreation Public/private domestic water supply Irrigation Livestock watering Industrial water supply Wildlife and hunting Fishing and boating Aesthetics Commercial navigation and transportation Hydro power	Temperature[1] Toxics (mercury) Chlorophyll *a*[2]

[1] A TMDL has been approved.
[2] Chlorophyll *a* was added in 2012 as a pollutant limiting water quality during the non-irrigation season.

Table 5.1-2
Idaho's designated uses (*Idaho Administrative Procedures Act* [IDAPA] 58.01.02. n.d.) and water-quality limiting pollutants (IDEQ 2014) for segments of the Snake River

Snake River Segment	Designated Uses	Pollutants
Snake River: Salmon River inflow to HCD	Cold-water aquatic life Salmonid spawning Primary contact recreation Domestic water supply Agricultural water supply Industrial water supply Wildlife habitats Aesthetics	Temperature[1] TDG[1]
Snake River: HCD to Oxbow Dam (Hells Canyon Reservoir)	Cold-water aquatic life Primary contact recreation Domestic water supply Agricultural water supply Industrial water supply Wildlife habitats Aesthetics	Temperature[1] TDG[1] Mercury
Snake River: Oxbow Dam to Brownlee Dam (Oxbow Reservoir)	Cold-water aquatic life Primary contact recreation Domestic water supply Agricultural water supply Industrial water supply Wildlife habitats Aesthetics	Temperature[1] Total phosphorus (TP)[1] TDG[1] Sediment[1]
Snake River: Brownlee Dam to Scott Creek (Brownlee Reservoir)	Cold-water aquatic life Primary contact recreation Secondary contact recreation Domestic water supply Agricultural water supply Industrial water supply Wildlife habitats Aesthetics	Temperature[1] DO[1] TP[1] Sediment[1] Mercury
Snake River: Scott Creek to Weiser River	Cold-water aquatic life Primary contact recreation Domestic water supply Agricultural water supply Industrial water supply Wildlife habitats Aesthetics	Temperature[1] DO[1] TP[1] Sediment[1]

[1] A TMDL has been approved.

5.2. Applicable SR–HC TMDL Targets

The Snake River has been identified as water-quality limited under § 303(d) of the CWA. This designation indicates the appropriate agencies have identified the water quality in the Snake River as not meeting applicable water-quality standards (ODEQ 2014; IDEQ 2014). Tables 5.1-1 and 5.1-2 list the pollutants identified as limiting water quality in the HCC reach of the Snake River.

Because the Snake River is border water, the SR–HC TMDL addresses Oregon and Idaho water-quality standards. The SR–HC TMDL uses the more stringent standard from either state to identify appropriate water-quality targets (Table 5.2-1). The states have both numeric and narrative standards, so both quantitative and qualitative levels may apply. IPC was issued allocations in the SR–HC TMDL for temperature, DO, and TDG.

Table 5.2-1
Levels indicating water-quality limitations for the Snake River from near Weiser, Idaho, to the confluence with the Salmon River (IDEQ and ODEQ 2004)

Measures	Levels Indicating Water-Quality Limitations
Water temperature[1]	A 7-day average maximum (7DAM) temperature greater than 17.8°C for designated uses: fish and aquatic life, anadromous fish passage, and salmonid rearing.
	A MWMT greater than 13°C when and where salmonid spawning occurs, or greater than a 0.14°C increase from anthropogenic sources when the site potential is greater than the target temperature.
DO[2]	A single water-column measure less than 6.5 milligrams per liter (mg/L) for fish and aquatic life designated uses year round upstream of HCD and outside of the spawning period downstream of HCD.
	A single water-column measure less than 11 mg/L or less than 95% of saturation; with a single intergravel measure less than 8 mg/L, measured as a spatial median, when and where salmonid spawning occurs.
TDG	A single water-column measure greater than 110% of saturation for designated uses: fish and aquatic life, anadromous fish passage, salmonid rearing, and salmonid spawning (when and where it occurs).
Nutrients	A growing season TP concentration greater than 0.07 mg/L.
Nuisance algae	A mean growing season concentration greater than 14 micrograms per liter (µg/L) chlorophyll a (a surrogate for algal mass) and a nuisance threshold of 30 µg/L exceeded greater than 25%.
pH	A single water-column measure less than 7 and/or greater than 9 pH standard units (SU) for designated uses: fish and aquatic life, anadromous fish passage, salmonid rearing, and salmonid spawning (when and where it occurs).
Mercury	A single total mercury water-column measure greater than 0.012 µg/L and/or methylmercury in fish tissue greater than 0.35 milligrams per kilogram (mg/kg) for designated uses: fish and aquatic life, salmonid rearing, and salmonid spawning (when and where it occurs).
Bacteria	A single sample greater than 406 *Escherichia coli* (*E. coli*) organisms per 100 milliliters (ml) and a 30-day logarithmic mean greater than 126 E. coli organisms per 100 ml based on a minimum of 5 samples for the primary contact recreation designated use.
Sediment	A 14-day average total suspended sediment greater than 80 mg/L and a monthly average greater than 50 mg/L for designated uses: fish and aquatic life, salmonid rearing, and salmonid spawning (when and where it occurs).

Table 5.2-1 (continued)

Measures	Levels Indicating Water-Quality Limitations
Pesticides	Single water-column measure greater than 0.024 nanograms per liter (ng/L) dichlorodiphenyltrichloroethane (DDT), 0.83 ng/L dichlorodiphenyldichloroethane (DDD), 0.59 ng/L dichlorodiphenyldichloroethylene (DDE), and/or 0.07 ng/L dieldrin for designated uses: fish and aquatic life, salmonid rearing, and salmonid spawning (when and where it occurs).

[1] The ODEQ numeric criteria (OAR 340-041 n.d.) have changed since the approval of the SR–HC TMDL. Anadromous fish migration corridors and redband trout criteria are a 7DAM temperature of 20°C. The seasonal thermal pattern of the Snake River must reflect the natural seasonal thermal pattern (NSTP). All point sources and nonpoint sources are restricted to a cumulative increase no greater than 0.3°C above the applicable criteria.
Idaho approved site-specific numeric criteria (IDAPA 58.01.02.286. March 29, 2012) since the submission of the SR–HC TMDL to protect fall Chinook salmon spawning and incubation in the Snake River from HCD to the Salmon River. From October 23 through November 6, the weekly maximum temperature (WMT) must not exceed 14.5°C. From November 7 through April 15, the WMT must not exceed 13°C.
A 7-day average cannot be calculated until there are 7 consecutive days of record. The first day is October 29.
Both Oregon and Idaho have NCC. Natural thermal potential conditions supersede numeric criteria.

[2] Lower levels are allowed when conditions of barometric pressure, altitude, and temperature preclude attainment of the numeric criteria.

6. Water-Quality Standards Evaluation

Since the HCC is located on border water, IPC assessed HCC water-quality data against the applicable standards in both Oregon and Idaho and load allocations for the HCC in the SR–HC TMDL (IDEQ and ODEQ 2004). In Section 7. Proposed PME Measures, IPC proposes a comprehensive *Temperature Management and Compliance Plan* (TMCP) that will include as its centerpiece the development and implementation of a suite of robust upstream Snake River in-river and tributary measures that provide temperature, water-quality, and habitat benefits to the Snake River above, within, and below the HCC (referred to herein as the Snake River Stewardship Program [SRSP]) to provide reasonable assurance that SR–HC TMDL load allocations and applicable water-quality standards will be addressed.

6.1. Temperature

Solar radiation is the primary natural heat source responsible for the temperature of surface water. Other important natural sources of surface-water heating and cooling are atmospheric air temperature, evaporative cooling from wind, heat loss or conduction, temperature of inflow streams, and geothermal heating of sediments or tributary hot springs. Anthropogenic heat sources may include direct, point-source thermal discharges and indirect, nonpoint-source influences of flow alteration and habitat modification. The latter contribute to increased thermal loads by altering the hydrologic regime, geomorphic channel characteristics, and riparian vegetation, which influence the amount of natural solar radiation reaching the water. Any heat source, whether natural or anthropogenic, influences the thermal characteristics of water.
While the temperature of water is important and most standards are based on an absolute temperature, temporal or spatial changes, such as annual thermal stratification, are the most important physical events contributing to a lake or reservoir’s thermal structure. It is this thermal structure that drives many of the chemical and biological processes and influences the biological communities present.

CWA § 303(d) requires states and tribes to identify and prioritize water bodies that do not meet water-quality standards and to develop a water-quality improvement plan (i.e., a TMDL) that ensures the attainment of the water-quality standards. The EPA must approve the TMDLs. Oregon lists the Snake River in the SR–HC TMDL reach as limited by temperature during the summer (ODEQ 2013). EPA (2001) added temperature to Idaho's § 303(d) list in 1998 for the Snake River downstream of HCD. Idaho (IDEQ 2013) later added temperature as a pollutant limiting water quality in the Snake River upstream of, as well as throughout, the HCC. There are a number of EPA-approved temperature TMDLs in the Snake River watershed upstream of the HCC, as well as an EPA-approved temperature TMDL for the Hells Canyon stretch of the Snake River (the SR–HC TMDL). The intended purpose of these temperature TMDLs is to provide a roadmap for bringing the respective water bodies into compliance with water-quality standards.

Temperature loading calculations performed by the IDEQ and ODEQ for the SR–HC TMDL demonstrated the dominant causes of elevated temperatures in the Snake River are natural non-anthropogenic heating and anthropogenic heat sources that have not been precisely quantified, such as upstream and tributary impoundments, water withdrawals, channel straightening and diking, and the removal of streamside vegetation (IDEQ and ODEQ 2004). The SR–HC TMDL stated it is difficult to determine the natural temperature conditions for such a highly regulated system or how altered current conditions differ from natural conditions (IDEQ and ODEQ 2004). As a result of these anthropogenic impacts and natural non-anthropogenic heating, the Snake River upstream of Brownlee Reservoir exceeds applicable temperature criteria during the critical months of June through September. In this context, the SR–HC TMDL (2004) determined these natural and non-quantifiable human influences preclude the attainment of the salmonid rearing and cold-water criteria upstream of the HCC during these summer months.[15] The SR–HC TMDL did not assign the HCC a load allocation for exceedances of the aquatic life and salmonid rearing criteria below HCD. The presence of the HCC reduces downstream summer peak temperatures, as excessively warm water resulting from upstream conditions are held in Brownlee Reservoir. The HCC does not add heat to the river; in fact, water discharging from HCD in the summer is cooler than the high summer temperature of water entering Brownlee Reservoir. However, the HCC also delays fall cooling downstream for similar reasons.

The SR–HC TMDL observed that numeric salmonid spawning criteria in the fall are exceeded during the first few weeks of the spawning period for SRFC salmon in most years. It also noted limited data collected in the 1950s suggest criteria were also exceeded before the completion of the HCC dams in the 1950s.[16] The SR–HC TMDL determined that if water flowing into Brownlee Reservoir met the upstream temperature standards in the months (i.e., summertime cold-water aquatic life standards) preceding the salmonid spawning season, outflow from the HCC would exceed the salmonid spawning criteria by only a "small margin." Therefore, the SR–

[15] See the SR–HC TMDL, p. 465.

[16] "A general evaluation of pre-impoundment data shows that monthly averages above 13°C occurred at the beginning of the salmonid spawning period identified by this TMDL and extended for approximately 2 weeks." SR–HC TMDL, p. 384.

HC TMDL concluded the HCC is responsible for the approximately 2-week exceedance of the salmonid spawning criteria. To address this, it presented an analysis to assess the influence of the HCC on water temperatures downstream and to develop a temperature load allocation for the project using inflow temperatures measured at Brownlee Reservoir as an estimate of site potential in the Snake River downstream of the HCC.[17] Site potential was defined as the temperature predicted to have occurred with direct sources of heat (predominantly natural atmospheric inputs) to the mainstem Snake River without the influence of the HCC but assuming the current altered hydrologic regime, climate, and tributary inputs (IDEQ and ODEQ 2004).

The SR–HC TMDL issued both load and waste load allocations to IPC. The HCC waste load allocations are for the 3 NPDES permits issued for the Brownlee, Oxbow, and Hells Canyon projects. The SR–HC TMDL set HCC's load allocation below HCD using the most stringent numeric criteria when the inflow temperature was less than criteria or set an allowable increase from anthropogenic sources when the inflow temperature was greater than numeric criteria. Oregon and Idaho have issued IPC a thermal load allocation for the outflow from HCD of no greater than a MWMT of 13 degrees Celsius (°C) when inflow temperature to Brownlee Reservoir is less than a MWMT of 13°C or no more than a 0.14°C increase in water temperature when inflow is greater than a MWMT of 13°C (IDEQ and ODEQ 2004).[18] The load allocation applies from October 23 through April 15 for salmonid spawning and November 1 through March 30 for mountain whitefish spawning. The SR–HC TMDL provided that the actual excess thermal load relative to the issued load allocation is dependent on a temperature exceedance and a flow rate (i.e., cfs) and can be expressed in terms of energy (e.g., calories). The SR–HC TMDL further provided that "[s]pecific compliance parameters for meeting [HCC's] load allocation will be defined as part of the 401 Certification process." [19]

This application therefore addresses the HCC thermal load allocation to obtain certification pursuant to CWA § 401. In the following sections, IPC compares measured temperature data from an extensive historic dataset with the most stringent standards in both Oregon and Idaho. Consistent with the approach used to establish water-quality targets in the SR–HC TMDL (IDEQ and ODEQ 2004), where standards have been updated after the completion of the SR–HC TMDL, IPC presents a new analysis relative to the most stringent criteria. IPC also presents an analysis of the thermal load exceedances at the HCC outflow relative to the SR–HC TMDL

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[17] On October 7, 2003, IPC filed a petition for judicial review in the Circuit Court for Baker County, Oregon, (Case No. 03-678) challenging those portions of the SR–HC TMDL that impose a temperature load allocation on the HCC. This petition is still pending; it has been extended annually by agreement between IPC and the State of Oregon and approval of the court. Nothing in this application is intended or should be interpreted as a waiver or relinquishment of the claims set forth, or that may be set forth, in that litigation. This notwithstanding, IPC proposes PME measures in this CWA § 401 application that address temperature effects of the HCC downstream of HCD.

[18] At the time the SR–HC TMDL was adopted, Oregon had a "no measureable increase" criterion, which was defined as 0.25°C. That criterion was replaced by a cumulative human use allowance of 0.3°C See OAR 340-41-28(12)(b).

[19] See SR–HC TMDL, p. 469.

load allocation and establishes the HCC outflow cumulative thermal load to be offset by upstream restoration actions that reduce thermal loading to the river. Proposed measures to address this cumulative thermal load exceedance are presented in Section 7.1. Temperature Proposed Measures.

Since many of the numeric criteria are broadly developed and applied to large geographic areas to protect beneficial uses, the following sections also present information relative to key beneficial uses when appropriate (e.g., additional data available on the status of SRFC salmon, the primary salmonid spawning beneficial use below HCD). SRFC salmon redd counts and natural returning adults below HCD have been increasing under the existing thermal regime. In its January 27, 2011, comments on a previous 401 temperature proposal for the HCC, NOAA Fisheries indicated the current temperature conditions are not limiting SRFC salmon production, but rearing habitat for juveniles is limited below HCD and is the most significant concern for the recovery of SRFC salmon (see Section 7.1.2.4.1.3. Summary Review of TCS Options).

6.1.1. Temperature Standards and SR–HC TMDL Targets

The application of temperature standards in Oregon and Idaho is similar. Both states have 5 types of temperature standards: 1) biologically based criteria that ensure thermally protective conditions; 2) natural conditions (as determined by the states) that supplement the biologically based criteria;[20] 3) air temperature exclusion criteria that allow for the exceedance of numeric and natural conditions; 4) human-use allowance or natural background conditions, which allows small increases in heat due to anthropogenic sources; and 5) site-specific criteria, requiring water-body-specific rulemaking based on the unique characteristics of the watershed.

The aquatic life beneficial-use classifications are for waters that are suitable, or intended to be made suitable for, the protection and maintenance of viable communities of aquatic organisms of significant aquatic species (IDEQ and ODEQ 2004). Resident and anadromous salmonids exist in the HCC and Snake River, and the applicable biologically based criteria are dependent on their distribution. Resident salmonids, particularly redband trout, are present upstream of HCD. Anadromous salmon and steelhead inhabit the Snake River downstream of HCD. Highly productive populations of cool- and warm-water aquatic species exist in the HCC reservoirs. These species predominantly include smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*), and channel catfish (*Ictalurus punctatus*) (Richter and Chandler 2003). More detail on the resident fish community of the HCC reservoirs is available in Technical Report E.3.1-5 of the *New License Application: Hells Canyon Hydroelectric Complex*.

[20] In *Northwest Environmental Advocates v. EPA et al.*, 855 F.Supp.2d 1199 (2012) (*NWEA*), Oregon's narrative NCC were invalidated by the court. Further litigation and settlement negotiations concerning Oregon's temperature water-quality standards are ongoing. In the interim, there are no substitute NCCs in place. As a result, IPC does not rely on the NCC for this application. This has direct implications for the application of the temperature load allocation given to the HCC, as explained in Section 7.1. Temperature Proposed Measures of this application.

Idaho and Oregon have different standards that apply to the same reaches of the Snake River at the same time. The following sections outline these various criteria.

6.1.1.1. Cold-Water Aquatic Life

Idaho temperature criteria for the protection of cold-water aquatic life are a daily maximum temperature not to exceed 22°C, with a maximum daily average temperature of no greater than 19°C (IDAPA 58.01.02.250.02.b). These criteria apply to the Snake River both at the inflow to the HCC, through the HCC reservoirs, and downstream of the HCC.

6.1.1.2. Redband or Lahontan Cutthroat Trout

Oregon temperature criteria for the protection of streams identified as having Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) or redband trout are a 7DAM temperature that may not exceed 20°C (OAR 340-041-0028(4)(e)). This criterion is applicable to the HCC reservoirs and Snake River upstream from RM 247.5 to RM 409.

6.1.1.3. Salmon and Steelhead Migration

In the SR–HC TMDL's evaluation of Oregon and Idaho water-quality standards, the then-existing Oregon numeric temperature criterion for salmonid rearing was identified as most stringent. That criterion provided for a 7DAM temperature of 17.8°C if and when the site potential is less than 17.8°C (IDEQ and ODEQ 2004). Therefore, the SR–HC TMDL applied this criterion for the inflows to the HCC reservoirs and the outflows from HCD from June to September[21]. Oregon has since revised its water-quality standards, including temperature standards. The EPA has approved these revisions. The revised standards follow EPA guidance, and the migration corridor use is designed "for waterbodies that are used almost exclusively for migrating salmon and trout during the period of summer maximum temperatures." EPA Region 10, Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards, at 28 (April 2003) (EPA Temperature Guidance).

The revised Oregon migration corridor requirement for salmon and steelhead includes a numeric 20°C 7DAM criterion that applies to the river downstream of HCD (OAR 340-041-0028(4)(d)). It is the same as the numeric criteria to protect redband and Lahontan cutthroat trout in the Snake River upstream of HCD (OAR 340-041-0028(4)(e)). In addition to the numeric criterion, this provision establishes narrative requirements that the river has cold-water refugia that are sufficiently distributed to allow for salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the stream[22], and a seasonal thermal pattern in the Snake and Columbia rivers that reflects the NSTP.

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[21] There are 2 exceptions in the SR–HC TMDL: The numeric criterion does not apply when 1) the temperature in excess is naturally occurring or 2) the daily maximum air temperature exceeds the 90th percentile of the 7DAM air temperature calculated over 10 years.

[22] The SR–HC TMDL (IDEQ and ODEQ 2004) acknowledged there are sufficient cold-water refugia downstream of the HCC.

6.1.1.4. Salmonid Spawning

Oregon and Idaho have criteria to protect spawning salmonids in areas and during times the species are present. In the SR–HC TMDL's evaluation of Oregon and Idaho water-quality standards, the then-existing (i.e., at the time of the SR-HC TMDL) numeric temperature criterion for salmonid spawning was identified as most stringent. That criterion provided for a MWMT temperature of 13°C if and when inflow temperature is less than 13°C (IDEQ and ODEQ 2004). The SR–HC TMDL stated that water-quality standards for salmonid spawning would apply only to that portion of the Snake River below HCD (RM 247 to RM 188) from October 23 through April 15 for SRFC salmon and November 1 through March 30 for mountain whitefish (IDEQ and ODEQ 2004). Oregon has since revised its water-quality standards, including temperature standards. Oregon's current salmon and steelhead spawning temperature criterion is a 7DAM temperature not to exceed 13°C (OAR 340-041-0028(4)(a)). On March 29, 2012, Idaho approved a site-specific numeric criteria for SRFC spawning and incubation in the Snake River downstream of HCD to the confluence with the Salmon River (RM 188 to RM 247.5) (IDAPA 58.01.02.286). The Idaho MWMT must not exceed 14.5°C from October 29 through November 6 and must not exceed 13°C from November 7 through April 15. Idaho submitted its site-specific temperature criteria for SRFC spawning to the EPA for approval on June 8, 2012. Because the EPA has failed to act on Idaho's adopted site-specific standard, this application addresses the current 13°C standard. As a result, the previous Idaho standard and Oregon's salmonid spawning criteria are the most stringent standards for the first 2 weeks of the spawning period. This criterion is applicable to the Snake River from RM 188 to RM 247.5 from October 23 through April 15 and from RM 169 to RM 188 from November 1 through May 15.

The IDEQ and ODEQ have interpreted the MWMT and the 7DAM temperature to be the mean of daily maximum temperatures measured over a consecutive 7-day period ending on the day of calculation. When used seasonally, as for spawning periods, the first applicable 7-day average occurs on the seventh day of the period. This interpretation is part of the IDEQ's site-specific numeric criteria (IDAPA 58.01.02.286) and an ODEQ Internal Management Directive (ODEQ 2008), both of which follow the EPA's recommended guidance (EPA 2003). The salmonid spawning temperature criterion below the HCC starts on October 23. Applying the criterion in accordance with IDEQ statutes, the ODEQ's interpretation, and the EPA's recommended guidance, the 7DAM is first calculated on October 29.

6.1.1.5. Human-Use Allowance Applied to Salmonid Spawning

The calculation described in the previous section does not, however, end the determination of the appropriate temperature standard to apply to this § 401 application. Oregon has revised its human-use allowance standard (OAR 340-041-0028(12)(b)) to include a cumulative increase from anthropogenic sources of no more than 0.3°C above the applicable criteria. This criterion was upheld by the U.S. federal district court for the district of Oregon. [23] Idaho has no explicit

[23] See NWEA II, 855 F.Supp.2d at 1218 n.8 ("Plaintiff's challenge to the EPA's approval of the 'Human Use Allowance' is rejected. OAR 340–041–0028(12)(b). It is clear that the EPA evaluated the potential for cumulative impacts and its approval of the Human Use Allowance was in no way arbitrary or capricious.").

human-use allowance. Idaho does have a natural background conditions standard that allows an increase in temperature of up to 0.3°C when standards are exceeded because of natural thermal influences (IDAPA 58.01.02.2000.09.63). The SR–HC TMDL describes Idaho's natural conditions allowance of 0.3°C as a "no-measurable-increase" provision of Idaho and Oregon water-quality standards. (See the SR–HC TMDL p. 394, Section 3.6.6.3; and p. 401, Section 3.6.8.1.). The SR–HC TMDL adopts the Oregon "no-measureable-increase" of 0.14°C as the more conservative standard. As noted above, Oregon's standard has been modified and approved by the EPA to a 0.3°C human-use allowance standard.

Idaho does not appear to have adopted either an explicit human-use allowance standard or even a "no-measurable-increase" standard. However, Idaho law does have a mechanism that authorizes Idaho to either waive or raise its temperature standards to match those set by Oregon's human-use allowance so there is no conflict over which state standard is the most stringent. IDAPA 58.01.02.070.07 provides:

> 07. Temperature Criteria. In the application of temperature criteria, the Director may, at his discretion waive or raise the temperature criteria as they pertain to a specific water body. Any such determination shall be made consistent with 40 CFR 131.11 and shall be based on a finding that the designated aquatic life use is not an existing use in such water body or would be fully supported at a higher temperature criteria. For any determination, the Director shall, prior to making a determination, provide for public notice and comment on the proposed determination. For any such proposed determination, the Director shall prepare and make available to the public a technical support document addressing the proposed modification. (4-5-00)

This provision is applicable in the circumstance of the temperature load below HCC during the salmonid spawning period. The director has already determined the beneficial use of salmonid spawning is the most sensitive use below the HCC and that it will be fully protected by a site-specific standard of 14.5°C during the first 2 weeks of the salmonid spawning period. That information has been made publicly available, subjected to notice and comment, and accepted by the Idaho Legislature in the approval of the rule. As mentioned previously, the EPA has approved Oregon's human-use allowance of 0.3°C, and that determination has been upheld in federal court. Applying a human-use allowance by waiving or raising the temperature standard by 0.3°C during this 2-week period will fully support the beneficial use of salmonid spawning, is supported by the record before the IDEQ, is the record and decision of the federal court, and is backed by the best available science. Therefore, in this application, IPC is requesting the IDEQ director exercise his/her discretion under IDAPA 58.01.02.070.07 to apply a 13.3°C standard to the load allocation assigned to IPC based on the SR–HC TMDL. A copy of the IPCs request is provided as Exhibit 6.1-1 to this application. Thus, the appropriate temperature standard evaluated in this § 401 application will be 13.3°C for the load allocation to IPC based on the SR–HC TMDL and will be the same under both Idaho and Oregon water-quality standards.

The SR–HC TMDL found that heat loads from NPDES-permitted outfalls in the HCC segment of the Snake River were *de minimus* and assigned no load to those outfalls for the salmonid spawning standard. The entire load for temperature exceedances of the salmonid spawning standard has been assigned to IPC[24]. Accordingly, the entire human use allowance should be applied to the IPC load.

6.1.2. Conditions Relative to Temperature

The following discussion assesses current conditions relative to the applicable Oregon and Idaho standards as outlined in the previous section. In IPC's view, the site-specific standard adopted by the IDEQ represents the best science on the appropriate temperature standard to protect SRFC spawning. However, because the EPA has failed to take action on the Idaho 14.5°C MWMT standard[25] within the time period required by the CWA, IPC will use the former Idaho 13°C MWMT and the Oregon 13°C 7DAM site-specific temperature criteria for purposes of this application, and, consistent with the above, adjust those criteria to 13.3°C.

6.1.2.1. Inflow Temperature

Current Idaho temperature standards require that the daily maximum temperature not exceed 22°C, with a maximum daily average temperature of no greater than 19°C (IDAPA 58.01.02.250.02.b). The Oregon migration corridor requirement for redband and Lahontan cutthroat trout includes a numeric 20°C 7DAM criterion that applies to the river upstream of HCD (OAR 340-041-0028(4)(e)). This criterion replaced the 17.8°C/site potential criterion analyzed in the SR–HC TMDL (IDEQ and ODEQ 2004). The Snake River flowing into Brownlee Reservoir exceeds both Oregon and Idaho applicable criteria throughout the summer every year (IDEQ and ODEQ 2004). IPC has measured Snake River temperature inflow to Brownlee Reservoir (RM 345.6) either hourly or every 10 minutes from 1996 through 2014. Due to the influx of heat into the system upstream of Brownlee Reservoir, Idaho's 19°C daily average criterion and Oregon's 20°C 7DAM criterion was exceeded every year when summer temperatures were measured. A summary of measured daily inflow temperature averages over the 1996 through 2014 period shows that during peak temperature times, the daily average ranged from 23°C to 28°C (Figure 6.1-2), therefore exceeding Idaho's daily maximum temperature standard of 22°C. Figure 6.1-2 shows daily average inflow temperatures over the 1996 through 2014 period as the average, maximum, and minimum daily average value of all years on a given day. 7DAM temperatures during peak temperature times ranged from 24°C to 28°C.

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[24] Again reference Baker County case, footnote #4.

[25] IPC will actively pursue formal adoption and approval of the 14.5°C site-specific standard in all appropriate forums. When adoption is complete, the 14.5°C site-specific standard will be the measure of the temperature obligation under this application.

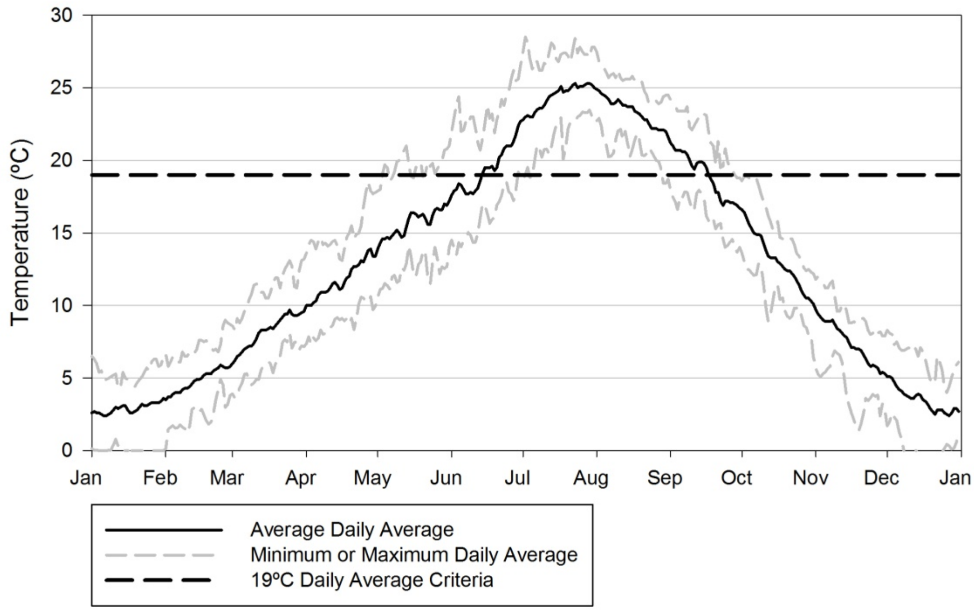

Figure 6.1-2
Average, minimum, and maximum daily average Snake River Brownlee Reservoir inflow temperature in °C for the 1996–2014 period of record (daily sample count ranges between 11 and 17).

The SR–HC TMDL presented a temperature-loading analysis to investigate the sensitivity of mainstem Snake River temperature to various thermal influences, including 1) groundwater, 2) point sources, 3) tributaries and agricultural drains, and 4) natural atmospheric and non-quantifiable influences. The loading analysis evaluated mainstem warming from the Idaho and Oregon border (RM 409) to Brownlee Reservoir inflow (RM 335) and concluded that natural atmospheric and non-quantifiable influences were the primary factors affecting temperature. EPA (2003) identified the 4 largest anthropogenic sources of increased temperature in the Pacific Northwest as 1) the removal of streamside vegetation, 2) channel straightening or diking, 3) water withdrawals, and 4) dams and impoundments. The SR–HC TMDL acknowledged that all these anthropogenic influences were not specifically evaluated in the loading analysis and, by default, were included in the non-quantifiable category of influences (IDEQ and ODEQ 2004).

Water withdrawal and consumptive use, upstream dams and impoundments, and the removal of streamside vegetation, coupled with reduced hyporheic connectivity (Hanrahan et al. 2007), have transformed some reaches of the Snake River upstream of Brownlee Reservoir from a cold-water river to a slow-moving, warm-water river supporting primarily non-game species of fish (Clark et al. 1998). Because these anthropogenic influences are significant thermal influences upstream of Brownlee Reservoir, they are presented below in greater detail to not only aid in understanding the effects these influences have on the temperature in the Hells Canyon reach of the Snake River but also in the eventual quantification of these influences.

The SR–HC TMDL recommends actions taken in relation to upstream TMDLs, currently developed to address the removal of riparian vegetation and to some extent channel morphology, be factored into temperature loading analyses for the SR–HC TMDL:

> Several upstream and tributary TMDLs have been completed, others are currently in process; still others will be initiated in the near future that may affect the water quality in the SR–HC TMDL reach. The current pollutant reductions identified by existing TMDLs have been incorporated in the loading analysis for the SR–HC TMDL to the extent possible. TMDLs currently in progress or scheduled for the near future will build on allocations developed by the SR–HC TMDL.
>
> All of these efforts will, collectively, be evaluated to determine future water quality benefits and long-term trends within the SR–HC TMDL reach. These assessments will be critical to the ongoing SR–HC TMDL process in order to monitor if identified reduction mechanisms are sufficient or if additional reductions may be necessary to meet water quality standards. [26]

Anthropogenic sources of increased temperature occur on a broad watershed scale. Their cumulative effect influences Snake River temperatures above the HCC, inflow temperatures to Brownlee Reservoir, the HCC outflow fall thermal regime and, as a result, the capacity of the HCC to meet the numeric salmonid life-cycle criteria.

6.1.2.1.1. Water Withdrawal and Consumptive Use

Water resources of the Snake River Plain upstream of Brownlee Reservoir are heavily influenced by irrigation and other uses. Consumptive water use on the Snake River Plain substantially depletes flow and results in increased water temperature. The storage and diversion of water changes the timing and magnitude of the seasonal flow regime. The SR–HC TMDL reported estimates that between 14.5 and 16.5 million acre-feet per year are diverted from surface water for irrigation supply. Goodell (1988) estimated, in 1980, approximately 12.6 million acre-feet of water were diverted by gravity or pumped from rivers and streams for the irrigation of approximately 2 million acres of land on the Snake River Plain (i.e., upstream from Weiser, Idaho). Goodell’s (1988) estimates included approximately 3.2 million acre-feet diverted from the Boise, Payette, Owyhee, Weiser, and Malheur watersheds combined. Of this, approximately 1.7 million acre-feet were diverted from the Boise River system (Table 6.1-2). Responding to diminished surface-water supplies, groundwater pumping has become an increasingly important water source, especially in the upper Snake River Basin (i.e., upstream from King Hill, Idaho). Clark et al. (1998) reported estimates that from 1980 to 1990 in the upper Snake River Basin, surface-water diversions may have decreased by approximately 10%, while groundwater pumping increased nearly 35%. This phenomenon of reduced surface-water diversions is also observed closer to the SR–HC TMDL reach of the Snake River. For the Boise River watershed, more recent diversion estimates are approximately 1.4 and 1.3 million acre-feet diverted in 1996 and 2000, respectively (Urban 2004). This is approximately 21% less water diverted than in 1980 (Goodell 1988).

[26] See SR–HC TMDL, p. 92.

Table 6.1-2
Summary of water diversions throughout the Snake River watershed in 1980 from Goodell (1988)

River Reach	Length of Reach (miles)	Total Diversions (acre-feet)
Snake River		
Snake River at Milner and upstream	214.9	6,936,160
Snake River at King Hill and upstream to Milner	92.1	101,340
Snake River at Weiser and upstream to King Hill	206.6	626,500
Major Tributaries		
Snake River tributaries upstream of Owyhee River	353.1	1,726,590
Owyhee River	27.3	539,580
Boise River	63.6	1,713,120
Malheur River	19.8	52,100
Payette River	38.4	812,110
Weiser River	14.9	90,640
Total	**1,030.7**	**12,598,140**

Goodell (1988) also estimated that overall consumptive use, including crops irrigated by surface water, groundwater, public supply, rural, industrial, and aquaculture, equaled approximately 5.1 million acre-feet. The consumptive use specific to the water evapotranspired by crops irrigated with diverted surface water was approximately 3.5 million acre-feet, approximately 30% of the 12.6 million acre-feet diverted. More recently, the SR–HC TMDL (IDEQ and ODEQ 2004) reported an overall consumptive use from surface-water diversions upstream of Brownlee Reservoir between 6 and 8 million acre-feet per year. Urban (2004) reported crop consumptive use near 45% of the diverted volume from the Boise River system. The remainder of the diverted volume evaporates from canal or soil surfaces, is evapotranspired by canal vegetation, remains in the soil, infiltrates to groundwater, or returns to streams.

The overall effect of consumptive use upstream of Brownlee Reservoir is the depletion of streamflow, which reduces the Snake River’s buffering capacity to atmospheric warming, increases residence time in the reservoir, and results in warmer water temperatures during summer months. This, combined with the sequential pattern of water withdrawal, use, and the return of water warmed on fields and through canal systems, results in an increasing effect on temperatures during spring and summer periods.

To estimate the effect of upstream diversion and consumptive use on Snake River flow into Brownlee Reservoir, IPC used a USACE estimate of unregulated flow upstream of the HCC. The USACE estimate accounted for storage and diversions (R. Delaney, USACE, pers. comm.). Essentially, the current computed local gage flow below storage facilities was adjusted based on operations or changes in storage. This was termed the adjusted local gage flow. From the adjusted local gage flow, diversion flows obtained from the Idaho Department of Water Resources (IDWR) were added. This iterative computation was carried throughout the Snake River watershed and resulted in an estimate of unregulated flow for the Snake River at Weiser, Idaho. The USACE unregulated flow estimate was calculated based on the daily average flow and, thus, incorporated seasonal variability in flow. Estimates of unregulated Snake River flow at Weiser were also available from the IDWR Snake River Planning Model (SRPM). The SRPM estimates were available on a monthly basis and compare well with the USACE estimates (Figure 6.1-3).

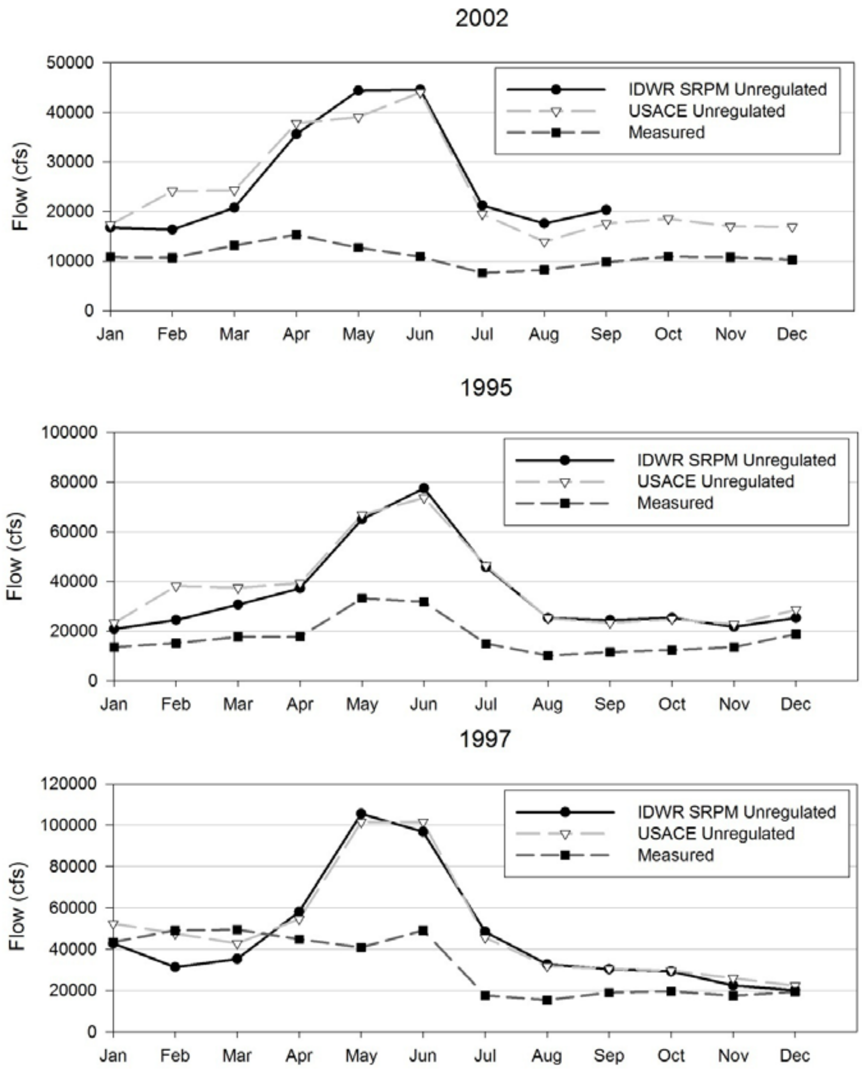

Figure 6.1-3
Comparison of IDWR SRPM and USACE monthly average unregulated Snake River flow estimates at Weiser, Idaho, for low (2002), medium (1995), and high (1997) water years. Monthly average measured flow at Weiser, Idaho (USGS gage 13269000), is also shown for comparison.

The USACE unregulated flow estimates show that the total annual Snake River volume entering Brownlee Reservoir may be lowered by 33 to 53% by current upstream water management and use (Table 6.1-3). The reduction in flow is largest during the spring runoff period and into July (Figure 6.1-4). During July, when Snake River temperatures typically peak, unregulated flow estimates were approximately 50% higher than measured flow.

Table 6.1-3
Comparison of measured (USGS gage 13269000, Snake River at Weiser) and unregulated (USACE unregulated Snake River flow at Weiser) Snake River volume at Weiser, Idaho (millions of acre-feet), during the calendar year for low (2002), medium (1995), and high (1997) water years

Year	Measured Inflow Volume (acre-feet)	Unregulated Inflow Volume (acre-feet)	Difference (acre-feet)	Percent Difference
2002	7.9	17.1	9.1	53%
1995	12.7	26.8	14.1	53%
1997	23.2	34.7	11.5	33%

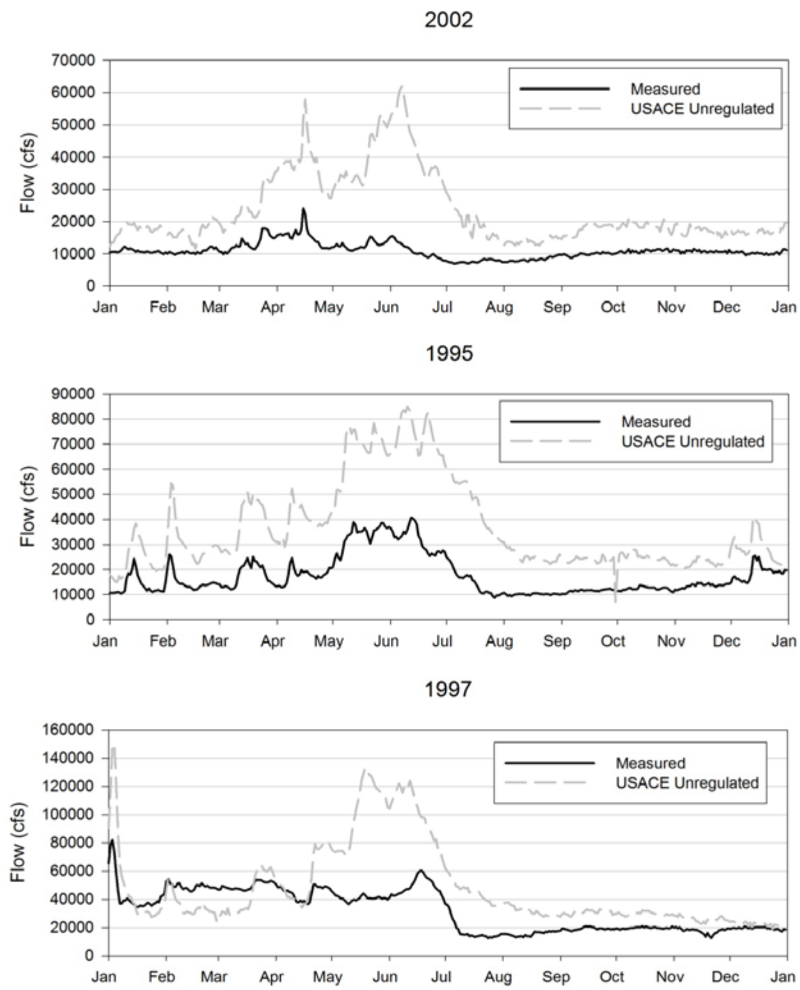

Figure 6.1-4
Daily average USACE unregulated and measured (USGS gage 13269000) Snake River flow at Weiser, Idaho, for low (2002), medium (1995), and high (1997) water years.

6.1.2.1.2. Dams and Impoundments

Water withdrawal and the use of Snake River water is facilitated by a complex network of reservoirs, diversions, canals, and pumping stations. Dams and impoundments contribute to

changes in the thermal regime by slowing water velocity and increasing residence times.
The IDWR lists a total of 572 dams on the Snake River and its tributaries upstream of HCD with a total storage capacity of approximately 11.8 million acre-feet (Table 6.1-4). The largest of these on the mainstem Snake River include the USBR American Falls Reservoir (1.7 million acre-feet) and Palisades Reservoir (1.4 million acre-feet). The largest reservoirs on the tributaries include 2 additional USBR reservoirs: Owyhee Reservoir on the Owyhee River (1.1 million acre-feet) and Cascade Reservoir on the Payette River (0.7 million acre-feet). The Boise River projects store an additional 1.1 million acre-feet. These include Anderson Ranch Reservoir (0.5 million acre-feet) and Arrowrock Reservoir (0.3 million acre-feet), both USBR projects, and the USACE project, Lucky Peak Reservoir, which stores 0.3 million acre-feet.

Table 6.1-4
Volume of water impounded and the percentage (%) impounded by owner in the entire Snake River watershed upstream of HCD and the SR–HC watershed (RM 247.6 409).

	Snake River Impounded Volume		SR–HC Watershed Impounded Volume		Upstream Impounded Volume	
Impoundment Owner	**acre-feet**	**%**	**acre-feet**	**%**	**acre-feet**	**%**
USBR	7,345,402	62	2,987,956	51	4,357,446	73
IPC	1,989,950	17	1,698,200	29	291,750	5
Other	1,361,852	11	902,991	15	458,861	8
USACE	307,000	3	307,000	5	0	0
U.S. Bureau of Indian Affairs	397,000	3	5,500	0	391,500	7
Big Wood Canal Company	191,500	2	0	0	191,500	3
Salmon River Canal Co. Ltd.	230,665	2	0	0	230,665	4
Total	**11,823,369**	**100**	**5,901,647**	**100**	**5,921,722**	**100**

IPC-owned dams account for nearly 2 million acre-feet, or 17% of the total storage capacity upstream of HCD (Table 6.1-4). In the portion of the Snake River watershed upstream of HCD that's included in the SR–HC TMDL (i.e., RM 409 to RM 247.6), the IDWR lists 380 dams on the Snake River and tributaries, with a total storage capacity of nearly 6 million acre-feet, of which IPC-owned dams account for approximately 29% based on total storage. On the Snake River and tributaries upstream of RM 409, there are 192 dams, with IPC-owned dams accounting for 5%.

6.1.2.1.3. Removal of Riparian Vegetation and Channel Modification

The removal of riparian vegetation increases direct solar radiation to the surface of a stream, thereby increasing heat loading to the stream and ultimately water temperature. As described earlier in Section 6.1. Temperature, there are many important natural sources of water heating and cooling, with solar radiation being the primary natural heat source responsible for the temperature of water (Brown 1970). Boyd and Casper (2003) and Shumar and de Varona (2009) consider shade and stream morphology factors that affect or control the amount of solar radiation intersecting a water surface. Shade is provided by surrounding vegetation and other physical features, such as hillsides, canyon walls, terraces, and high banks. Stream morphology affects how closely riparian vegetation grows. Additionally, these factors are the most likely to have been influenced by anthropogenic activities and activities that can be most readily addressed in the confines of a TMDL.

Wyoming has not currently developed any temperature TMDLs for Snake River hydrologic unit codes (HUC) (WDEQ 2012), and the EPA has approved only 1 in Oregon for the Upper Malheur (ODEQ 2012). Idaho has 27 EPA-approved temperature TMDLs for Snake River HUCs (IDEQ 2012). The temperature TMDLs approved by the EPA in Idaho have generally followed 2 methodologies: either a reduction in water temperature to meet numeric criteria or a heat load allocation based on potential natural vegetation (PNV).

Most recently, Oregon and Idaho have assigned heat load allocations to temperature-limiting streams through a similar process. The ODEQ has applied the Heat Source model module Shade-a-lator, and the IDEQ has applied a method to determine reduced solar radiation from PNV. Both describe the riparian plant community that provides system potential shade—a mature, site-potential, vegetated landscape. System potential shade is then used as a surrogate representing natural background temperatures. IPC believes that, while the ODEQ's Shade-a-lator module is more data intensive than the IDEQ's PNV methodology, the basic principles governing the effect of direct solar radiation to the stream surface are similar.

The EPA has approved heat load allocations calculated using the Heat Source model module Shade-a-lator and the PNV methodology on nearly 2,850 miles of rivers and streams in Oregon and Idaho.

Additionally, the IDEQ has prepared other temperature TMDLs using the PNV methodology but has not yet submitted them to the EPA for approval. More temperature TMDLs in Oregon and Idaho are likely as many more miles of rivers and streams are listed as limited by temperature (IDEQ 2010; ODEQ 2010).

6.1.2.1.4. Hyporheic/Groundwater Modification

Hyporheic flow along a river channel produces a moderating effect on water temperature (Poole and Berman 2001; Lancaster et al. 2005). Reduced hyporheic exchange can reduce the capacity for water temperature buffering. Hyporheic exchange occurs when surface water enters the riverbed and flows subsurface before returning to the main channel. An exchange of water between the water column and hyporheic zone is potentially one of the more important thermal buffering processes (Poole and Berman 2001). The beneficial effects of hyporheic exchange have been found to be significant in smaller streams, but relatively high exchange rates also occur in larger, unconstrained channels where gravel deposits can be reworked.

Hanrahan et al. (2007) studied hyporheic exchange characteristics in historic (i.e., Swan Falls area) and contemporary (i.e., below HCD) SRFC spawning areas. Measurements of hydrologic interactions between the river and the riverbed showed less movement of water through the riverbed in the Swan Falls area. In addition, the accumulation of silt and fine sand over the spawning gravels was significantly higher in the Swan Falls area and was correlated with reduced movement of water through the riverbed.

The Snake River below HCD does not have these hyporheic flow issues because the HCC assists in removing a large portion of the sediment and silts that would otherwise accumulate downstream. Therefore, the HCC provides a substantial benefit to downstream spawning gravels by capturing silt and sediment that would otherwise cover existing SRFC salmon spawning gravels similar to the Marsing reach. In fact, SRFC salmon spawning might not be possible below HCD without the sediment and silt accumulation that occurs in the HCC.

6.1.2.2. Reservoir Temperature

Impounding a riverine system changes the system's hydrodynamics and thermal structure. Brownlee Reservoir exhibits 3 identifiable zones with different temperature characteristics: 1) the riverine zone, 2) transition zone, and 3) lacustrine zone. These 3 zones are common in large reservoirs (Thornton et al. 1990). The riverine zone develops in the upstream reaches of a reservoir and is characterized by a temperature similar to that of the upstream river (i.e., a slower, broader river). The transition zone, as the name implies, is the reach of the reservoir between the riverine and lacustrine zones. The lacustrine zone (the zone farthest downstream) is characterized by lake-like hydrodynamics. Similar to lakes, the lacustrine zone exhibits thermal stratification with the classic strata: epilimnion, metalimnion, and hypolimnion that develop in early spring and persist through late fall (Figure 6.1-5). The vertical location of the metalimnion is relatively deep in Brownlee compared to natural lakes and is strongly influenced controlled by the physical configuration of the power intake channel from which the penstocks draw water, with the top of the metalimnion forming at the centerline elevation of the penstocks.

Acknowledging and understanding the complex hydrodynamics within Brownlee Reservoir is important in understanding the thermal effects of inflowing water on outflow temperatures. Specifically, the quantity and temperature of water entering the reservoir in the spring and summer affects outflow temperatures through the summer and fall. Even after the water has been physically evacuated from the reservoir, it has played a role in the ongoing thermal structure of the reservoir, which in turn affects outflow temperatures.

The thermal structure of Brownlee Reservoir is dependent on the water-year type (i.e., high, low, or average flow conditions). The most notable pattern that occurs is in higher water years when the USACE mandates that Brownlee Reservoir be drafted significantly for flood control. Significant drafting of Brownlee Reservoir for flood control results in a relatively warm hypolimnion because the cold winter water that would otherwise remain in the hypolimnion is mixed with inflow waters until a later date in the spring (Figure 6.1-5). More information relative to the thermal structure of Brownlee Reservoir and patterns among water years can be found in Technical Report E.3.2-2 of the *New License Application: Hells Canyon Hydroelectric Complex*.

Because of the temperature structure and hydrodynamics in Brownlee Reservoir and the location of the outlet structures, the temperature regime of water leaving Brownlee Reservoir is notably different than the inflowing temperature regime. Current conditions relative to criteria in Oxbow and Hells Canyon reservoirs are therefore driven by Brownlee outflow temperature (see Section 6.1.2.3. Outflow Temperature).

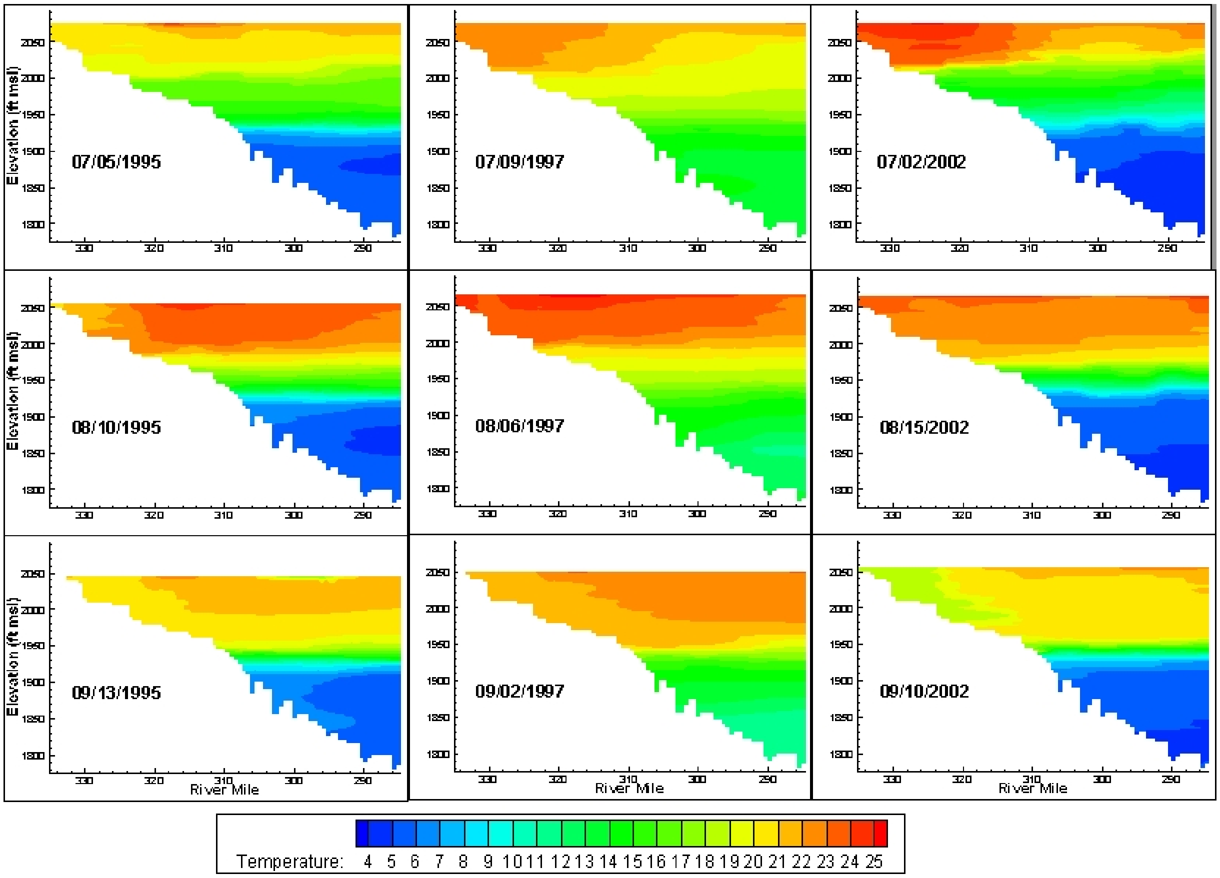

Figure 6.1-5
Measured Brownlee Reservoir temperature in °C, by river mileage and reservoir depth, for July, August, and September in an average (1995), high (1997), and low (2002) water year

6.1.2.3. Outflow Temperature

Idaho's EPA-approved temperature standards include a numeric 13°C MWMT salmonid spawning criterion (former IDAPA 58.01.02.286). Similarly, Oregon's temperature standards include a numeric 13°C 7DAM salmonid spawning criterion that applies to the river downstream of HCD (OAR 340-041-0028(4)(a), Table 121B). Idaho temperature criteria for the protection of cold-water aquatic life are a daily maximum temperature not to exceed 22°C, with a maximum daily average temperature of no greater than 19°C (IDAPA 58.01.02.250.02.b). The Oregon migration corridor requirement for salmon and steelhead includes a numeric 20°C 7DAM criterion that applies to the river downstream of HCD (OAR 340-041-0028(4)(d)). In addition to the numeric component, this OAR provision establishes narrative requirements that the river has cold water refugia that are sufficiently distributed to allow for salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the stream, and a seasonal thermal pattern in the Snake and Columbia rivers that reflects the NSTP. With respect to the effect of the HCC on outflow temperatures, the SR–HC TMDL noted that "if upstream conditions were cooler, the water exiting the HCC would also be cooler." Therefore, the SR–HC TMDL concluded the HCC is not contributing to temperature exceedances specific to the cold-water aquatic life and the salmon and steelhead migration designated use (IDEQ and ODEQ 2004). Accordingly, the SR–HC TMDL did not assign HCC a load allocation for exceedances of the aquatic life and salmon and steelhead migration criteria below HCD. Conversely, the SR–HC TMDL did issue a thermal load allocation to IPC for the outflow from HCD during the beginning of the salmonid spawning period.

Summer water temperatures are elevated throughout the Snake River; however, the duration and magnitude of exceedance were generally less in waters below the HCC than in inflow waters (Figure 6.1-6). Myers et al. (2003) attributed this summer cooling to the volume of cool water retained in Brownlee Reservoir. The cool water is retained because of the reservoir's depth and the strong summer thermal stratification of the water column. A portion of this cool water is delivered downstream through the summer because Brownlee Dam's intakes are located relatively deep in the water column (approximately 40 m below full-pool elevation).

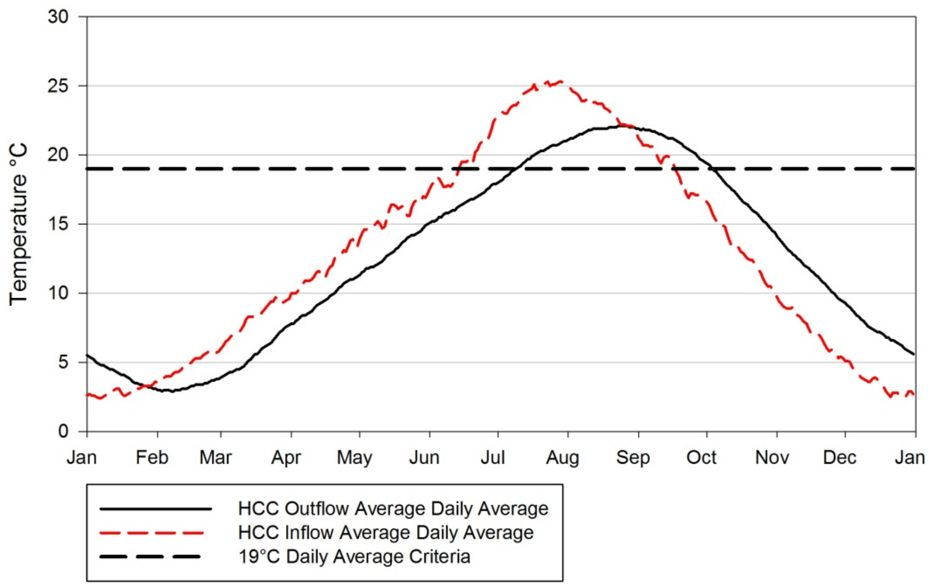

Figure 6.1-6
Daily average temperature in °C inflow to Brownlee Reservoir (period of record, 1996-2014) and outflow from HCD (period of record, 1991–2014) compared with Idaho's daily average 19°C criteria.

The data indicate that the magnitude of flows in a year affect the relative amount of cooling caused by the HCC. In high-water years, like the late 1990s, and more recently in 2011, when the USACE mandates the drafting of Brownlee Reservoir for flood control in the spring, relatively little summer cooling is evident (Figure 6.1-7). This is likely due to the fact that much of the accessible cool water (i.e., water above the intake elevation) has been drafted. There is an obvious trend to the summer cooling effect of the HCC in medium and low water years. In the low-water year 2002, there were as many as 40% fewer days the criterion was exceeded at the HCC outflow compared to the inflow and nearly a 7°C reduction in the maximum temperatures measured. More detail on the HCC's effect on water temperature is available in Technical Report E.3.2-2 of the *New License Application: Hells Canyon Hydroelectric Complex*.

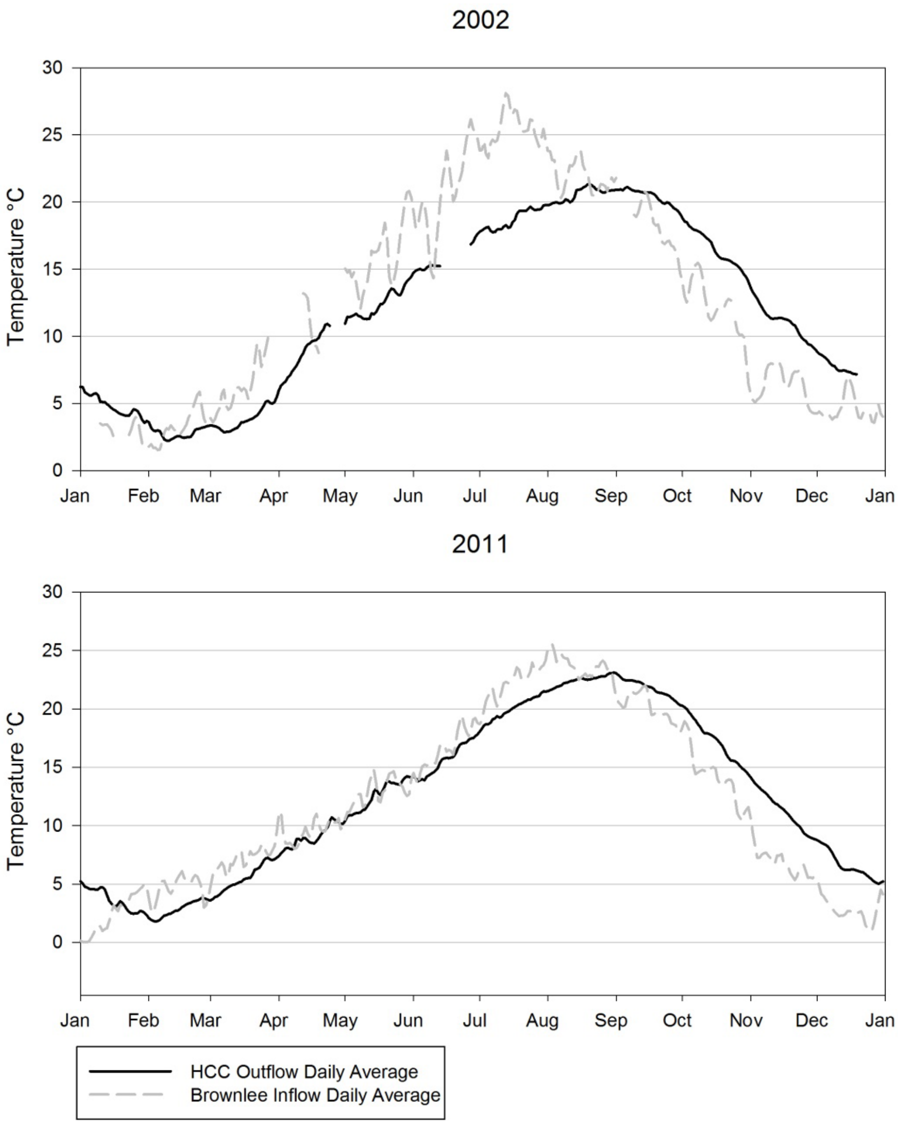

Figure 6.1-7
HCD outflow and Brownlee Reservoir inflow daily average temperature in a low (2002) and high (2011) water year.

This summer cooling effect of the HCC on Snake River temperatures has important benefits to aquatic life and salmonid rearing. Chandler et al. (2003) and Richter and Chandler (2003) found that fish communities downstream of Brownlee Dam favored cold-water indicator species more than those in Brownlee Reservoir and the Snake River upstream. The SR–HC TMDL corroborated this finding, stating that while aquatic life and salmonid-rearing use is impaired upstream in the Snake River, the use is supported in "other segments [of the HCC and Snake River downstream] due to the availability of coldwater refugia" (IDEQ and ODEQ 2004). This is a particularly important finding not only because OAR 340-041-0028(4)(d) requires "sufficiently distributed coldwater refugia[,]" but also in relation to biological criteria (biocriteria) (OAR 340-041-0011. Specifically, the availability of the cold-water refugia downstream of the HCC is of sufficient quantity and quality to support aquatic species and resident biological communities that are not supported in the Snake River upstream of the HCC (see Section 6.1.2.3.1.1. Cold-Water Refugia). The Snake River downstream of the HCC exhibits more natural river processes that provide high connectivity to hyporheic environments. This connectivity creates areas of downwelling and upwelling through alluvial deposits in the riverbed.

6.1.2.3.1. Salmon and Steelhead Migration and Cold-Water Aquatic Life

In Oregon, the beneficial-use designation downstream of HCD is salmon and steelhead migration corridors (OAR 340-041-0028(4)(d)). The Idaho cold-water aquatic life 19°C daily average criterion applies at the HCC outflow, as well as the inflow (IDAPA 58.01.02.250.02.b). Neither the water flowing into the HCC, nor the water flowing out of the HCC, is compliant with the 22°C, 20°C, or 19°C criteria at all times (Figure 6.1-6 and 6.1-8). However, water leaving the HCC is closer to compliance in both frequency and magnitude. Specifically comparing the Oregon 20°C 7DAM criterion, inflowing water is noncompliant an average of 91 days per year (period of record 1991–2014), while outflows are noncompliant 59 days (period of record 1996–2014). Further, inflows peak an average of 6.1°C over the 20°C criterion, while outflows peak an average of 2.2°C over the criterion (Figure 6.1-8).

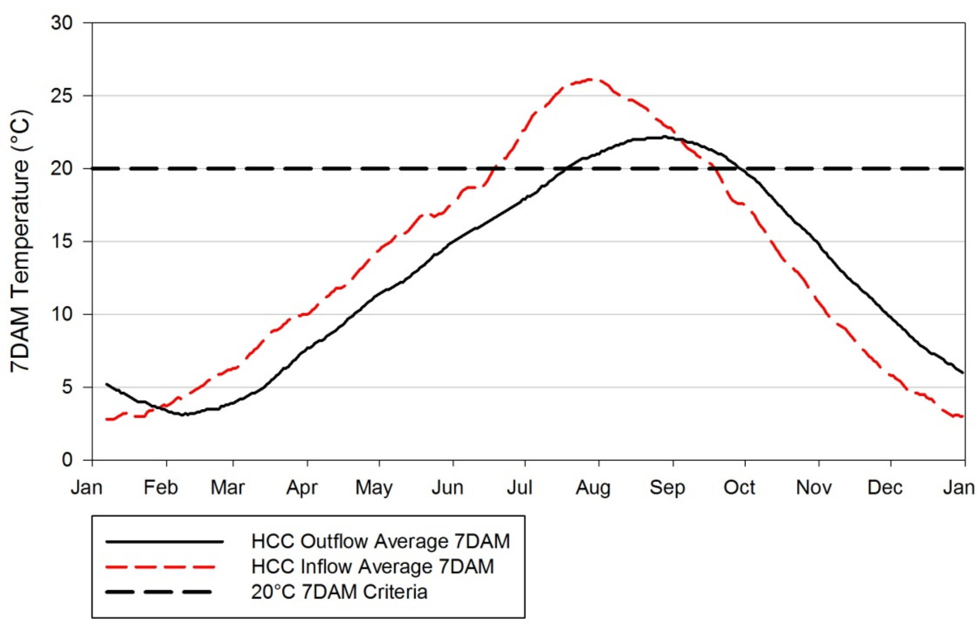

Figure 6.1-8
Average 7DAM temperature for water flowing into Brownlee Reservoir (HCC inflow average) and out of HCD (HCC outflow average) over the period of record. Average values on any given day are the average of the daily 7-day average maximum for each year over the period of record. The period of record for outflow is 1991 to 2014, and the period of record for Inflow is 1996 to 2014

Water temperature data from the inflows and outflows of the HCC demonstrate the HCC is not causing, nor contributing to, a violation of the 20°C Oregon criterion or the 19°C Idaho water quality criterion. In fact, they show the HCC is having a net positive effect relative to these criteria. This conclusion is consistent with the assessment in the SR–HC TMDL. The SR–HC TMDL concludes the HCC does not add heat to the river, warm summer temperatures in

Hells Canyon are caused by “natural” or “non-anthropogenic” influences, and anthropogenic activities not currently quantified or regulated upstream of the HCC.

The SR–HC TMDL supported this conclusion with an analysis of the measured temperature dataset available at that time and the results of IPC temperature modeling (SR–HC TMDL at 381; 402–04). The model scenario used temperature data collected in 1995. The temperature model showed that if inflows met the numeric temperature criteria, the outflow at HCD would also meet the numeric temperature criteria for cold-water aquatic life and salmonid migration. The SR–HC TMDL specifically concluded “if upstream conditions were cooler, the water exiting the HCC would also be cooler. Therefore, it is concluded the HCC is not contributing to temperature exceedances specific to the cold-water aquatic life/salmonid migration designated use.” For this reason, the SR–HC TMDL does not assign a temperature load allocation to the HCC with regard to the time period and conditions outside the salmonid spawning period.

In sum, the SR–HC TMDL concluded the HCC is not responsible for elevated Hells Canyon temperatures in the summer months and, therefore, continued operations of the HCC following relicensing will not cause or contribute to a violation of either the 19°C Idaho or the 20°C Oregon numeric criteria. While exceedance of the numeric criteria is not attributable to the HCC, IPC’s proposed SRSP will help make progress toward attainment of these criteria both upstream, within, and downstream of the HCC by improving the upstream conditions that are the source of current summer temperature exceedances (See Section 7.1. Temperature Proposed Measures).

6.1.2.3.1.1. Cold-Water Refugia

The first of the 2 Oregon narrative criteria related to migration requires “coldwater refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body” (OAR 340-041-0028(4)(d)). The purpose of the refugia criterion is to ensure there are pockets of cooler water available to migrating fish during the time of peak summer temperatures in excess of 20°C. See EPA Temperature Guidance at 29.

The SR–HC TMDL concludes that, both within and downstream of the HCC, the “designated beneficial uses are being supported through availability of cold water refugia” (TMDL at 422). This conclusion is founded on a population study of fish above, in, and below the HCC that documented fluvial populations of rainbow trout in the HCC and fluvial populations of rainbow trout and bull trout downstream of the HCC. Fluvial trout are not found upstream of the HCC. (Chandler et. al 2003). The study further showed that the rainbow trout populations in the HCC and rainbow trout and bull trout downstream were using cold-water refugia provided by the tributaries during summer months by either migrating upstream into the tributaries or associating with the cold-water plume of the tributaries during the summer months. Fluvial populations of rainbow trout and bull trout move out of the tributaries into the reservoirs or the river below HCD to over-winter.

The finding in the SR–HC TMDL is consistent with recent studies that demonstrate river temperatures are often more complex than previously thought (Fullerton et al. 2015) and that cold-water refuges are present at multiple spatial scales created by a variety of controls, such as geomorphology, tributary influence, and groundwater exchange points (Ebersole et al. 2015; Fullerton et al. 2015). Between HCD and the Clearwater River confluence, there are

132 perennial streams distributed throughout the length of the Snake River corridor (see Exhibit 6.1-2) that may provide some thermal refugia not only from the surface flow and plumes of these streams, but also through hyporheic and groundwater upwelling through the alluvial fans associated with the streams. Ebersole et al. (2015) conservatively defined cold-water patches as discrete areas of relatively cold water that were ≥3°C colder than the ambient stream temperature. While not a complete data set of all perennial streams, temperature data of surface flows collected by Idaho Power in 2003 and 2004 at many of the perennial streams in Hells Canyon shows that during the critical summer months of July through September, the majority of the perennial streams measured would provide refugia (Exhibit 6.1-2). These measurements do not include the potential additional benefit of subsurface flow upwelling into the Snake River at these stream mouths. Ebersole et al. (2015) also found that many tributaries with dry channels also provided significant cold-water patches in mainstem rivers through hyporheic and groundwater upwelling during the time of year with the warmest water temperatures. There are 813 drainages in the Hells Canyon corridor that are classified as intermittent streams. The extent that these perennial and intermittent streams provide thermal refugia has not been measured but may be significant relative to thermal refugia. Based on these studies, and consistent with the SR–HC TMDL, the refugia criterion is currently attained within the downstream reach of Hells Canyon affected by the HCC and will not change as a result of relicensing and continued HCC operations.

The SR–HC TMDL does, however, conclude there is a lack of cold-water refugia upstream of the HCC due to the degradation of the upstream watershed (see TMDL at 422). While the HCC does not impact the availability of upstream cold-water refugia and therefore requires no mitigation under this § 401 application, Section 7.1. Temperature Proposed Measures of this application describes the mechanism for how IPC's proposed SRSP will aid in addressing the lack of upstream refugia habitat identified in the SR–HC TMDL, while also offsetting IPC's cumulative thermal load exceedance during the salmonid spawning period. In addition to decreasing the amount of thermal load that enters the upstream tributaries, the riparian revegetation and in-stream projects proposed as part of the SRSP will also create extensive new habitat designed to promote cold-water refugia.

6.1.2.3.1.2. Natural Seasonal Thermal Pattern

The second narrative criterion associated with the migration corridor use is a requirement that "the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern" (OAR 340-041-0028(4)(d)). This criterion is not further defined in rule or Internal Management Directive, and has not yet been applied in other contexts. Therefore, in this section, IPC presents its understanding of the intent behind the criterion and its application to the HCC.

Like the refugia criterion, the NSTP criterion is intended to minimize the exposure of migrating fish to peak 20°C or greater temperatures. In its Temperature Guidance document, the EPA explained the relationship among the 3 components of the migration corridor standard as follows:

> To protect this use, EPA recommends a 20°C maximum 7DADM numeric criterion plus a narrative provision that would require the protection, and where feasible, the restoration of the natural thermal regime. EPA believes that a 20°C criterion would protect migrating

> juveniles and adults from lethal temperatures and would prevent migration blockage conditions. However, EPA is concerned that rivers with significant hydrologic alterations (e.g., rivers with dams and reservoirs, water withdrawals, and/or significant river channelization) may experience a loss of temperature diversity in the river, such that maximum temperatures occur for an extended period of time and there are little cold water refugia available for fish to escape maximum temperatures. In this case, even if the river meets a 20°C criterion for maximum temperatures, the duration of exposure to 20°C temperatures may cause adverse effects in the form of increased disease and decreased swimming performance in adults, and increased disease, impaired smoltification, reduced growth, and increased predation for late emigrating juveniles (e.g., fall Chinook in the Columbia and Snake Rivers). Therefore, in order to protect this use with a 20°C criterion, it may be necessary for a State or Tribe to supplement the numeric criterion with a narrative provision to protect and, where feasible, restore the natural thermal regime for rivers with significant hydrologic alterations. (EPA Temperature Guidance at 29)

In 2011, the ODEQ confirmed that the intent of the Oregon NSTP standard reflects the EPA's intent to protect the migration corridor use. Specifically, the ODEQ stated the following:

> Review of DEQ rulemaking files indicates that the intent of the NSTP language was to protect migrating fish from temperatures routinely exceeding the 20°C criterion. Attainment of NSTP would allow the migrating fish to experience varying temperatures, not constant warm temperature. (Memorandum from ODEQ Water Quality Division to IPC, June 30, 2011)

That the protection of the migration corridor use is the singular focus of the NSTP criterion is consistent with the rulemaking history of the migration corridor standard. During the rulemaking, the ODEQ specifically rejected a recommendation from its Technical Advisory Committee (TAC) to apply the NSTP to the salmon and steelhead spawning use rather than the migration corridor use. The TAC recommended the ODEQ not adopt a numeric spawning standard and instead adopt a narrative standard requiring "regulated rivers" to "take all feasible steps to mimic the natural thermal regime" ODEQ temperature TAC meeting notes (July 1, 2003). The ODEQ instead adopted a numeric standard of 13°C for the spawning use and a narrative NSTP for the migration use. This is evident in that the NSTP language is present only in subsection (4)(d) for migration corridors, but not present in the other subsections addressing other salmonid uses, including salmonid spawning. Therefore, consistent with the ODEQ's action during the rulemaking and the applicable regulations, NSTP is associated only with the migration corridor use and is intended to minimize the duration of peak temperatures in excess of 20°C downstream of the HCC.

The presence of the HCC reservoirs has resulted in a subtle temporal shift of seasonal temperatures relative to inflowing water and what occurred prior to construction of the HCC (Figure 6.1-9). While quantitative values can be assigned to this shift, because the NSTP standard was intentionally established as a narrative standard, quantification is not appropriate. The intent of the NSTP standard, consistent with the EPA temperature guidance, was to protect migrating fish from temperatures above 20°C if the thermal regime of the system had been altered, resulting in the extended duration of temperatures over 20°C. Figure 6.1-8 shows the HCC is not creating conditions whereby migrating fish are being exposed to substantially extended periods of temperatures in excess of 20°C, and when temperatures are above 20°C, the outflow is typically cooler than the inflow.

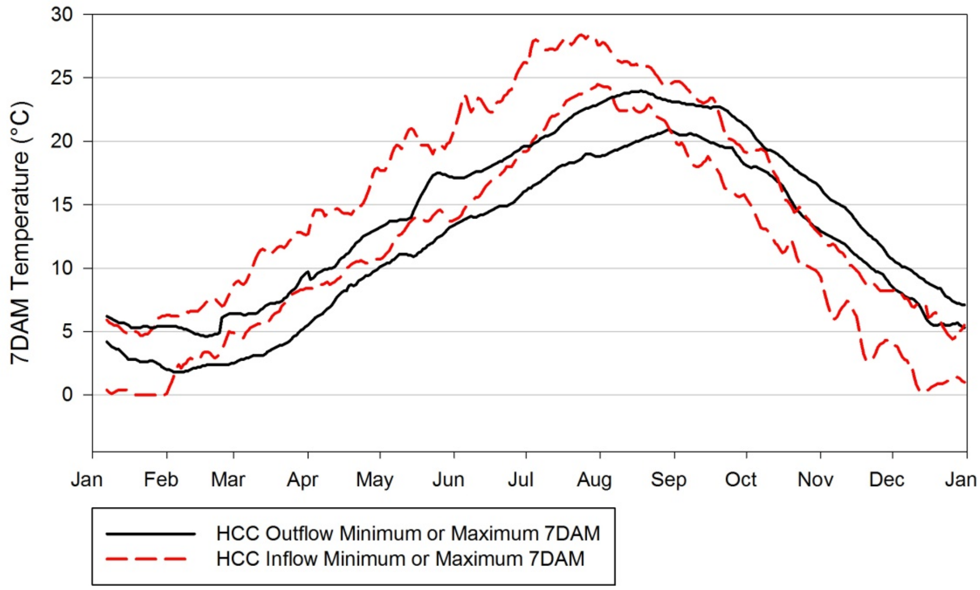

Figure 6.1-9
Minimum and maximum 7DAM temperature for water flowing into Brownlee Reservoir (Inflow Minimum or Maximum) and water flowing out of HCD (Outflow Minimum or Maximum). The period of record for outflow is 1991 to 2014, and the period of record for Inflow is 1996 to 2014.

The EPA temperature guidance indicates it may be necessary to supplement the numeric criterion with a narrative provision like NSTP to address the concern "that rivers with significant hydrologic alterations (e.g., rivers with dams and reservoirs, water withdrawals, and/or significant river channelization) may experience a loss of temperature diversity in the river, such that maximum temperatures occur for an *extended period of time* and there is little cold-water refugia available for fish to escape maximum temperatures." The HCC does not cause a condition where "maximum temperatures occur for an extended period of time." In fact, the potentially harmful maximum temperatures measured in the inflowing water to Brownlee Reservoir are not found in water flowing from HCD because of the cooling effect of the HCC when inflows exceed 20°C.

Therefore, the HCC does not create the type of condition the NSTP criterion was meant to address, and the continued operation of the HCC will be in compliance with the NSTP criterion. Moreover, as noted above, there are adequate cold-water refugia below the HCC for migrating fish to escape maximum summer temperatures. Further, IPC's proposed SRSP provides additional reasonable assurance that the NSTP criterion will be met below HCD (See Section 7.1. Temperature Proposed Measures).

6.1.2.3.2. Salmonid Spawning

The SR–HC TMDL used Idaho's criterion, which at the time was a MWMT of 13°C. Similarly, Oregon's salmon and steelhead spawning temperature criterion is a 7DAM temperature not to exceed 13°C (OAR 340-041-0028(4)(a)). Under current regulations, the numeric spawning criteria can be increased by up to 0.3°C to account for anthropogenic influences (see Section 6.1.1.4. Salmonid Spawning).[27] The SR–HC TMDL presented and discussed HCC outflow temperature exceedances of the numeric salmonid spawning criterion based on the data set available at that time. The SR–HC TMDL also recognized that the actual thermal load exceedance for the HCC on any one day is dependent on both the temperature of the outflow and the flow on that day. Accordingly, the SR–HC TMDL documented a methodology to calculate an excess thermal load per day. IPC applied this methodology to a current dataset consisting of 22 years of measured data to calculate the excess thermal load on each day, for each year, when the HCC outflow temperature was above the salmonid spawning criteria (13.3°C). The daily excess thermal loads were then summed to calculate a cumulative thermal load exceedance for each year. Throughout the 22-year time period, the HCC cumulative thermal load exceedance above a 13.3°C 7DAM salmonid spawning criterion ranged from 0.0 to 1,044.9 billion kilocalories (bkcals) (Table 6.1-5). The variability exhibited by the dataset is not unique to environmental data, but it does pose challenges from a regulatory perspective in defining a target load for the HCC. Frequently in the regulatory arena, statistics are used to define an appropriate target based on a range of collected environmental data (Exhibit 6.1-3). Therefore, in calculating the size of its cumulative thermal load exceedance for 401 certification, IPC used the 90th percentile statistic, calculated from the period of record, 1991 to 2014. This results in a calculated cumulative thermal load exceedance at the HCC outflow of 550.7 bkcal. The 90th percentile cumulative thermal load exceedance represents the total excess heat load expected to be discharged from the HCC during all but the most extreme exceedance periods, and it is meant to account for all of the days the HCC outflows would not meet the spawning criterion. The following is a more detailed description of how this cumulative HCC outflow thermal load exceedance was calculated using the 90th percentile value.

6.1.2.3.2.1. Calculation Methodology and Results

For each year in the 22-year period, thermal load exceedances above the numeric 7DAM spawning criteria (13.3°C) were calculated for the period when the HCC outflow temperature was above the salmonid spawning criteria. Beginning October 29 of each year in the 22-year period—which is the first applicable day during that period for which 7DAM can be calculated (see Section 6.1.1.4. Salmonid Spawning)—measured HCC outflow temperature data was compared to the numeric 7DAM salmonid spawning criterion (i.e., 13.3°C). The temperature criterion was exceeded in the Snake River downstream of HCD in all but 1 year (Table 6.1-5). The elevated temperatures that exceed the criterion occurred during the first few weeks of the SRFC spawning season (Exhibit 6.1-4 and 6.1-5). For each day of each year in the 22-year period where the 7DAM temperature measurement exceeded the salmonid spawning criterion, measured flow data from the HCD outflow was also used. The actual measured temperature exceedance on each day over the duration for each year was combined with the average HCC

[27] When the SR–HC TMDL as approved, Oregon included an allowable anthropogenic increase of up to 0.14°C. SR–HC TMDL, p. 468. The TMDL incorporated the Oregon standard because it was more stringent than the Idaho standard at the time, which included an allowable anthropogenic increase of up to 0.3°C. Oregon standards now include allowable anthropogenic increases up to 0.3°C.

outflow volumes on that day to calculate a daily thermal load exceedance using the following equation from the SR–HC TMDL:

$$Thermal\ Load\ (\frac{bkcal}{day}) = \left(Q\,\frac{cf}{sec} * \Delta T(℃) * \frac{28.324kg}{cf} * \frac{86400sec}{day} * \frac{1kcal}{\frac{kg}{1}℃}\right)/1{,}000{,}000{,}000$$

Where:

- Q = Daily average HCC outflow in cfs
- ΔT = The magnitude of exceedance above the 13.3°C criterion based on the 7DAM temperature

The daily thermal load exceedances for each year, which are documented in Table 3 of Exhibit 6.1-5, were then summed to calculate a cumulative thermal load exceedance for each year's salmonid spawning period (see the Cumulative Thermal Load Exceedance column in Table 6.1-5 and Exhibit 6.1-5). The cumulative approach incorporates the thermal exceedances observed each day that the outflow temperature exceeds the daily salmonid spawning criterion. By summing all observed daily thermal exceedances into a cumulative thermal load exceedance, this approach accounts for the entirety of the excess pollutant load (magnitude) observed during the spawning period (duration). The 22 years where sufficient data existed to calculate the cumulative thermal load exceedance were varied, with cumulative thermal load exceedances ranging from 0.0 to 1044.9 bkcal (Table 6.1-5, Figure 6.1-10). This range of cumulative thermal load exceedances represents the variable flow, climatic, and meteorological conditions that have been observed during the salmonid spawning period over the last 22 years. The cumulative thermal load exceedances followed the same general pattern as temperature exceedances with the highest observed exceedances in low water years.

Table 6.1-5
HCC outflow 7DAM temperature, exceedance of the 7DAM salmonid spawning criterion of 13.3°C on October 29, and the cumulative thermal load exceedance over the duration of time when the HCC outflow temperature was greater than 13.3°C. Available data over the 1991 through 2014 period is included. Also shown for reference is the annual average Snake River flow in cfs measured at Weiser, Idaho, and water-year category.

Year	7DAM Temperature (°C)	Criteria Exceedance (°C)	Duration (days after 10/29)	Cumulative Thermal Load Exceedance (bkcal)	Annual Average Flow (cfs)	Water-Year Category
1991	16.4	3.1	12	453.2	10,400	Low
1992	15.8	2.5	16	551.0	8,400	Low
1993	15.7	2.4	NA	NA	16,500	Medium
1994	15.5	2.2	12	353.0	10,800	Low
1995	14.6	1.3	7	114.8	17,500	Medium
1996	14.8	1.5	8	150.2	24,600	High
1997	13.3	0.0	0	0.0	32,000	High
1998	14.0	0.7	6	58.7	23,000	High
1999	14.5	1.2	8	181.4	22,900	High
2000	15.0	1.7	9	192.9	15,100	Medium
2001	NA	NA	NA	NA	9,800	Low
2002	15.3	2.0	8	210.3	11,000	Low
2003	16.8	3.5	13	547.7	11,700	Low
2004	16.3	3.0	15	500.4	10,900	Low
2005	15.7	2.4	15	456.0	11,100	Low
2006	15.3	2.0	8	184.9	21,500	Medium–high
2007	14.5	1.2	9	116.3	11,000	Low
2008	14.9	1.6	10	175.1	12,700	Low
2009	14.6	1.3	6	95.2	14,400	Medium–low
2010	16.8	3.5	20	809.9	13,300	Medium–low
2011	15.4	2.1	11	428.0	24,900	High
2012	15.8	2.5	16	438.1	15,800	Medium
2013	15.3	2.0	10	277.4	9,700	Low
2014	16.9	3.9	21	1,044.9	11,200	Low

Note: NA indicates HCC outflow temperature data was not collected over the entire duration, so an accurate cumulative thermal load exceedance could not be calculated for that year.

Because of the variability exhibited by the dataset, statistical analysis is used to define an appropriate cumulative thermal load exceedance based on a range of collected environmental data. In a number of analogous regulatory contexts, regulators have used a 90% statistic to set appropriate compliance targets from a range of environmental data (see Exhibit 6.1-3). The =PERCENTILE function in Microsoft Excel was used to calculate the 90th percentile value of the cumulative thermal load exceedance totals for each year listed in Table 6.1-5. The 90th percentile cumulative thermal load exceedance for the 1991 to 2014 period is 550.7 bkcal (Figure 6.1-11). IPC proposes that 550.7 bkcal represent the thermal load assigned to the HCC in the SR–HC TMDL. This cumulative thermal load exceedance quantifies the thermal effects of the HCC relative to the salmonid spawning criterion and defines the compliance target for mitigating the effects within the framework described in Section 7.1. Temperature Proposed Measures.

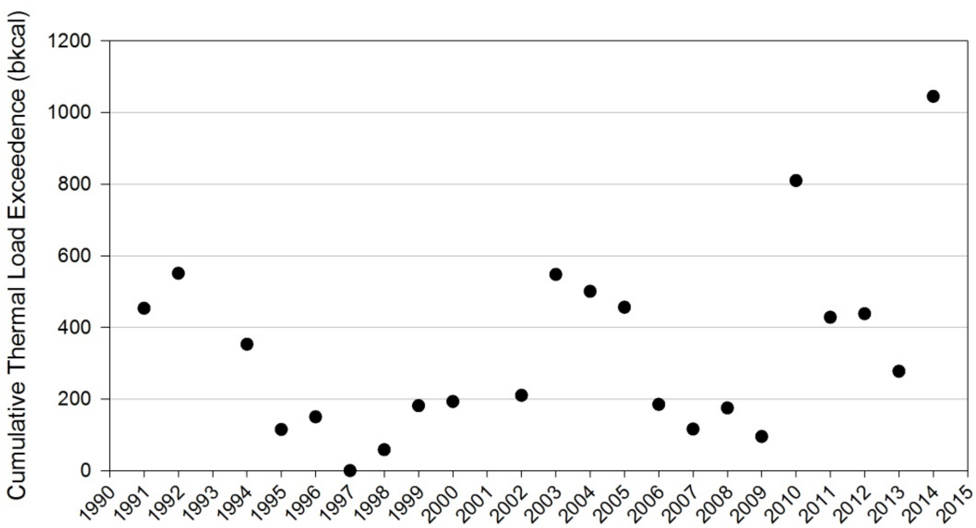

Figure 6.1-10
Cumulative thermal load exceedance in bkcal for each year, chronologically, during the 1991 through 2014 period

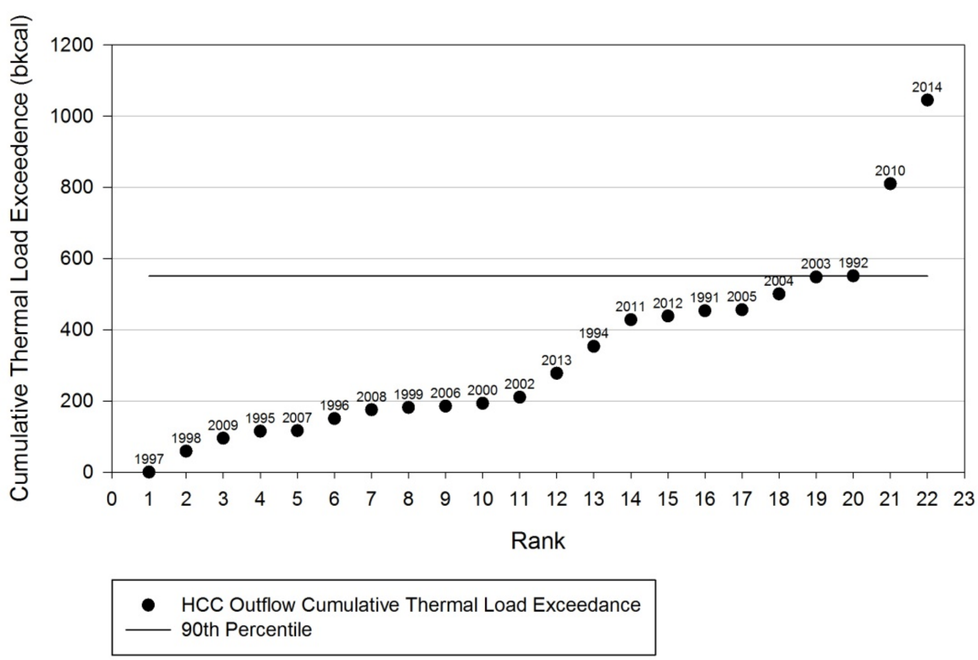

Figure 6.1-11
Plot ranking the cumulative thermal load exceedances in bkcal for the 22 years available during the 1991 through 2014 period. Labels are included showing the individual years. The 90th percentile of the dataset, 550.7 bkcal, is shown as the solid line.

6.1.3. Snake River Fall Chinook Life History and Status

The previous section compared and discussed current HCC outflow conditions with a narrow focus on the applicable criteria. However, a narrow comparison of current conditions with criteria is only 1 step in the analysis; it is also important to consider the criteria are designed with the specific intent of beneficial use protection and support, in this case SRFC salmon spawning. Substantial information exists relative to the history, changes, and current status of SRFC salmon. A summary of this information is presented below and suggests that while there are documented criteria exceedances during the first 2 weeks of the SRFC salmon spawning season, the beneficial use of salmonid spawning is being supported downstream.

The present-day Snake River spawning and incubation habitat from what is now Brownlee Reservoir through Hells Canyon to near the confluence of the Grande Ronde River (RM 169) was neither extensively used by, nor particularly conducive to, SRFC salmon for spawning and incubation before the construction of the HCC. Spawning of SRFC salmon occurred from about the confluence of the Grande Ronde River downstream to the confluence of the Snake and Columbia rivers. However, the more significant population of SRFC salmon was located primarily from the confluence of the Boise River (RM 392) up to Shoshone Falls (RM 615). Following the construction of Swan Falls Dam (RM 458) in 1901, SRFC salmon spawned primarily in the Marsing reach of the Snake River, which extends between Swan Falls Dam and the town of Marsing, Idaho (RM 424). The Snake River in Hells Canyon was primarily used as a migration corridor to and from these upstream reaches of the Snake River. From the onset of development in southern Idaho, altered hydrographs and high sediment and nutrient loads in the Snake River in the area upstream of Brownlee Reservoir have contributed to the significant degradation of these historic spawning habitats. Since, and unrelated to, the construction of Brownlee Reservoir, this upstream spawning habitat has become too degraded to support SRFC salmon spawning because the intergravel environment has become anoxic and infiltrated with fine sediments (Groves and Chandler 2005).

Following the construction of Brownlee Reservoir, efforts were made to pass SRFC salmon to spawning habitats in the Marsing reach. Passage was not successful for juvenile SRFC salmon, and passage efforts ceased in 1964. HCD was completed in 1968 and became the upstream terminus for migration. Spawning habitats in the lower Snake River were lost with the construction of the federal Lower Snake River dams, beginning in 1962 with the completion of Ice Harbor Dam and going through 1975 with the completion of Lower Granite Dam. This construction further limited spawning in the Snake River to the approximately 100 miles of free-flowing river between HCD and Lower Granite Reservoir. Today, spawning is distributed throughout the entire 100-mile reach. In contrast to past upstream habitats, today spawning habitats below HCD are relatively clean of fine sediments, and the intergravel environment is well oxygenated with high connectivity to the water column. Fine sediments from southern Idaho and eastern Oregon land uses are primarily captured in the HCC reservoirs. SRFC salmon continue to increase in numbers as various measures and hatchery supplementation programs have been implemented to enhance this population. In 2013 and 2014, near record numbers of SRFC salmon redds—approaching 3,000 in both years—were observed in the Hells Canyon reach. Adult returns above Lower Granite Dam in 2013 exceeded 50,000, of which approximately 21,000 were naturally produced adults. In summary, the habitat in the Hells Canyon reach has changed from primarily a migration corridor for SRFC salmon with limited spawning to habitats that now support extensive spawning and incubation for SRFC salmon. This, in part, is the result of a changed thermal regime of the Hells Canyon habitat caused by the construction of the HCC, which resulted in warmer fall and winter temperatures relative to the pre-HCC thermal regime. The thermal environment below the HCC now supports incubation and emergence timing similar to the historic habitats upstream of the HCC, whereas historically the HCC was a colder incubation environment that would have delayed emergence timing. This thermal regime change is significant to the status of SRFC salmon. NOAA Fisheries concurs, “the current water temperature regime downstream from HCD is more beneficial to SRFC than the natural regime, primarily due to warmer fall and winter water temperatures that accelerate fry emergence.”

6.1.3.1. Snake River Thermal Regimes

SRFC salmon have a varied history of different thermal regimes. Adults migrate in late summer and early fall when summer maximum temperatures are at or near their peak. They spawn during a declining thermal pattern in the fall. These thermal regimes vary among years and spawning locations, influenced by differences in water year and air temperatures. Despite this variability, adult migration and spawn timing has changed very little over the period of record. This suggests significant plasticity in their ability to adapt and function in variable thermal regimes and a reliance on more stable cues for these events, such as a photoperiod.

The core population of SRFC salmon historically occupied the mainstem Snake River primarily upstream of Swan Falls Dam. They were closely associated with the warmer winter thermal regime of the Middle Snake River, which was significantly influenced by the discharge of the Eastern Snake Plain Aquifer (ESPA). The thermal pattern of the Snake River is unique from other rivers because of the high volume of groundwater stored in the ESPA that enters the Snake River between approximately RM 553 and RM 620. In total, approximately 5,000 cfs of groundwater enters the Snake River in the form of springs that flow from basalt cliffs, primarily on the north side of the river. Development rates of incubating embryos increase with water temperature, and emergence timing is dependent on when spawning occurs and the accumulated thermal units (ATU) through incubation. SRFC salmon reach emergence around 1,000 ATUs. The warmer incubation temperatures influenced by the ESPA allowed for early emergence from spawning areas, where fish would rear for a brief period before migrating to the ocean. This typical life history for fall Chinook salmon is referred to as an ocean type or Age-0 life history, where fish migrate to the ocean in their first year of life. This life history is dependent on early emergence to allow sufficient growth to migrate before summer water temperatures become unsuitable. This is compared to an Age-1 type life history for some Chinook salmon, where fish will rear during the first year in freshwater and migrate to the ocean as a 1-year old fish. The thermal regime for Age-1 life histories must be cool enough to support summer rearing, which was not likely in the arid desert environment of the mainstem Snake River. Today, fall Chinook salmon that spawn in the Clearwater River emerge relatively late and typically display an Age-1 life history, because releases of cold water from Dworshak Reservoir have created cooler conditions in the lower Clearwater and Snake rivers.

The influence of the ESPA diminishes downstream, especially when larger tributaries, such as the Boise and Payette rivers, enter the Snake River. Prior to the construction of the HCC, the Snake River in Hells Canyon was relatively cold, and fish would have emerged late relative to those upstream in the Swan Falls reach and would have had to rear and migrate during warm summer temperatures. This thermal regime was very similar to the Salmon River, which historically has not supported significant SRFC salmon spawning. When Brownlee Reservoir and Dam were constructed and blocked migration, it also created a thermal shift with warmer fall temperatures. The reservoir also moderated winter temperatures to be warmer than what historically occurred below Brownlee Dam. This new thermal regime created conditions for emergence timing comparable to below Swan Falls Dam and continues today to support the Age-0 life history.

To illustrate this effect, the mean of the daily average water temperatures was plotted from several locations in the Snake River (Figure 6.1-12). These data sets include the Snake River at Bliss Dam (RM 560) and Swan Falls Dam (RM 458) and the Snake River before it enters into Brownlee Reservoir (RM 345) for the time period 1996 to 2006 (IPC, unpubl. data.). The Bliss Dam is located downstream of the majority of spring flow. A fourth data set includes the Snake River at RM 273 (pre-Oxbow Dam site) and includes mean daily average temperatures from 1954 to 1957, prior to the effect of the HCC (FWS 1957, 1958). For comparative purposes, a fifth data set includes the mean daily average temperature of the Salmon River measured at RM 1 for the time period 1996 to 2006. These data sets demonstrate that the thermal regime in the pre-HCC time period was colder during winter months than the upstream locations, had comparable maximum (though slightly cooler) summer temperatures at the inflow and Swan Falls locations, and summer was substantially warmer than the Bliss Dam location (Figure 6.1-13). With the exception of the spring months during spring run-off, the thermal regime of the pre-HCC time period was very similar to that of the Salmon River today (Figure 6.1-13) that enters the Snake River at RM 188. Construction of Brownlee Dam (1958) modified the thermal regime in the Hells Canyon reach of the Snake River, causing 1) delayed fall cooling, 2) increased winter base temperatures, 3) delayed spring warming, and 4) cooler summer temperatures relative to inflow conditions. This modification of the thermal regime is represented by using the mean daily average temperature of the Snake River measured below HCD for the time period 1996 to 2006 (Figure 6.1-13).

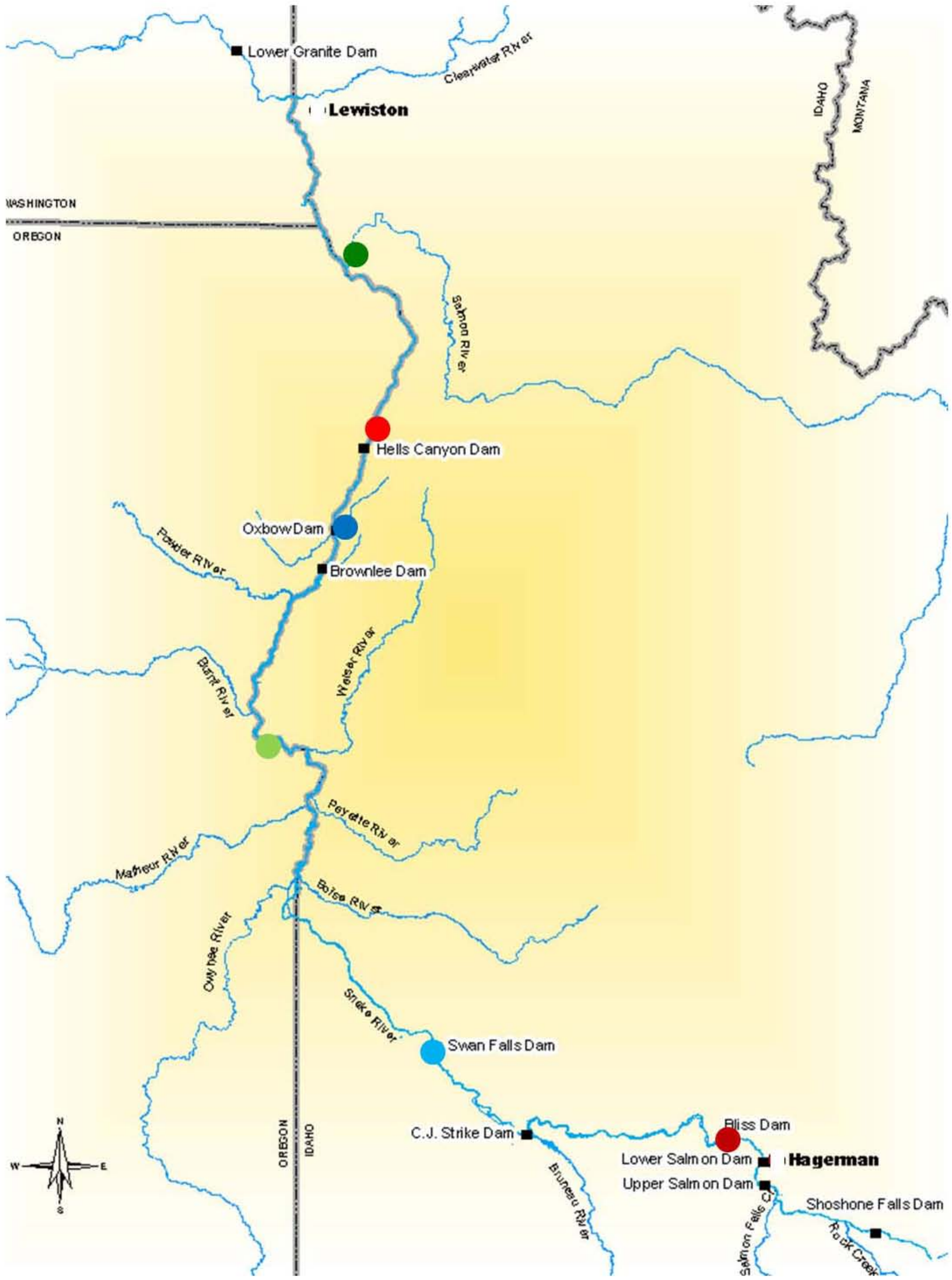

Figure 6.1-12
Locations along the Snake River where temperature data sets used for comparisons of thermal regimes were collected. They include Bliss Dam (dark red circle; RM 560), Swan Falls Dam (light-blue circle; RM 458), the inflow into Brownlee Reservoir (light-green circle; RM 345), near present-day Oxbow Dam (dark-blue circle; RM 273), and below HCD (light-red circle; RM 247). Another data set used for comparison was collected in the Salmon River at RM 1.

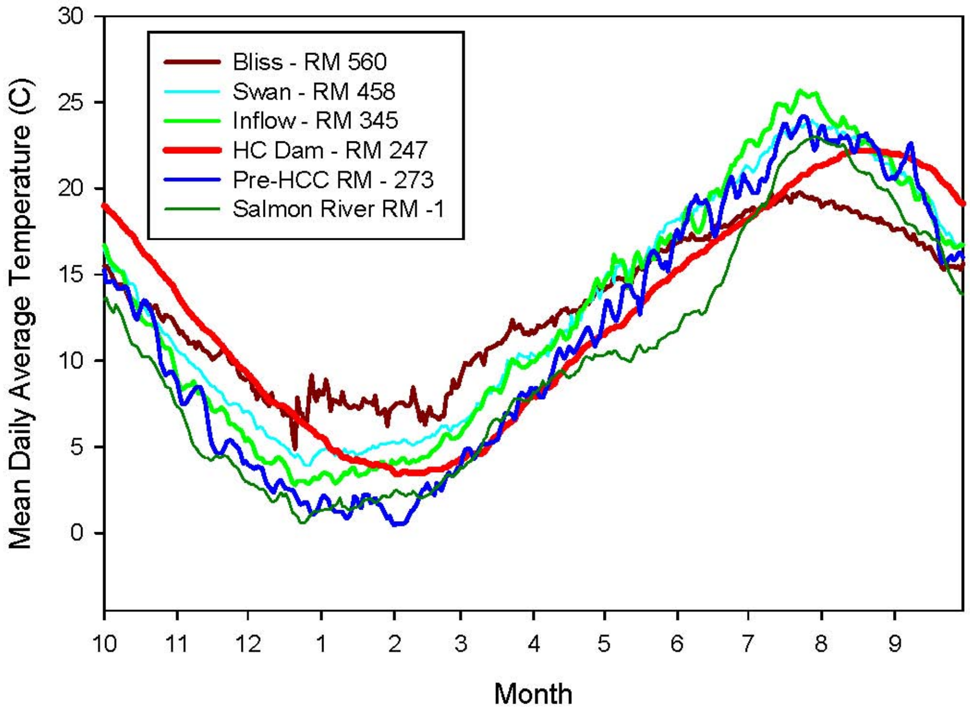

Figure 6.1-13
Mean daily average water temperature in °C that represents thermal patterns of the Snake River for the time period 1996–2006 at Bliss Dam (RM 560), Swan Falls Dam (RM 458), a location above the inflow to Brownlee Reservoir (RM 345), HCD (RM 247), and the Salmon River (RM 1) and for the time period 1954–1957 for the pre-HCC location at RM 273.

6.1.3.2. SRFC Salmon Spawning, Incubation, and Emergence Periods

Because SRFC salmon spawn during a declining fall thermal regime in all environments, earlier spawners initiate spawning in temperatures warmer than later spawners. In the Snake River, under the current thermal regime, spawning can initiate in water temperatures exceeding 16°C. Similar observations of spawning occur in other fall Chinook salmon populations, including the Hanford reach of the Columbia River. Thermal characteristics are different in all of the major spawning areas, such as the upper and lower Snake River (above or below the Salmon River), various sections of the Clearwater (above or below the North Fork), and the Grande Ronde and Imnaha rivers. Geist et al. (2006) compared incubation success of SRFC salmon under different initial spawning temperatures and a declining thermal regime to a winter base temperature comparable to what is observed in the Snake River. Geist et al. (2006) did not find significant differences in survival among initial incubation environments at temperatures between 16.5°C and 13°C.

The spawning period for SRFC salmon observed today and historically in reaches upstream of the HCC do not differ greatly, despite the different thermal regimes. Surveys were not conducted at the same level of detail as those in Hells Canyon over the last 20 years, so definitive historic start and end dates for comparison are difficult to determine. Today, some of the earliest spawning observed in the Snake River is during the second week of October. The peak spawning period (the median distribution of redd observations for the years 1993–2009) is November 4. The latest spawning observations are generally near the second week in December.

Evermann (1896) reported observations of ripe and spent fall Chinook salmon in a fishery at Millet Island in 1894. The fishery began on October 1 and extended through October 31. Their first observed spent female in the fishery was on October 10, which comports well with present-day observations. Ripe fish were still being captured at the close of the fishery, suggesting spawning continued after November 1. An observation reported by Evermann from an interview with a seine fisherman near Glenns Ferry (RM 539) reported observing carcasses through the first half of November. Similarly, below Swan Falls Dam, Zimmer (1950) reported 3 redds observed in the first week of October 1947, with a peak number of redds counted on the November 6 flight, and spawning was generally completed by the end of the first week in December. These observations comport very well with what is observed today in the Snake River and what is observed in other populations, such as the Hanford reach of the Columbia River. With this information, for purposes of comparing emergence timing among historic and present-day reaches of river, the application of the present-day spawning distribution to the various thermal regimes to estimate differences in emergence timing among those locations is reasonable.

Emergence timing reflects the different thermal patterns of the Snake River and demonstrates a negative linear relationship with river mile (Figure 6.1-14). The linear relationship further suggests cooling of the Snake River progressed at a predictable rate with distance from the large inflow of the ESPA. Emergence timing in the primary historic spawning area as represented by the Bliss Dam temperature regime would have been early, with a median emergence date of March 1. Median emergence dates became later as spawning progressed downstream such that below Swan Falls Dam the median emergence date would be more than 1 month later on April 7. In reaches further downstream, including the inflow to Brownlee Reservoir and the pre-HCC Oxbow Dam site—sites that did not support significant spawning—the median emergence dates are estimated to have been April 25 and May 11, respectively. Today, with the influence of the HCC (principally, Brownlee Reservoir), the shift in the thermal regime has shifted the median emergence date to April 17, close to what was observed below Swan Falls Dam (Figure 6.1-14), which supported significant SRFC salmon spawning prior to the construction of the HCC.

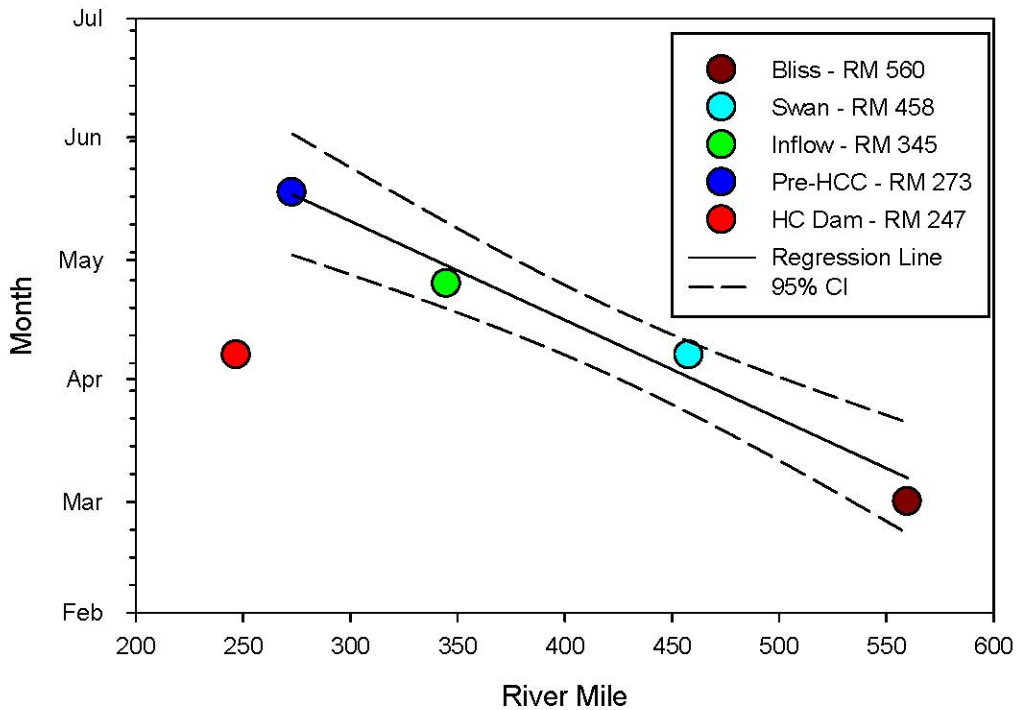

Figure 6.1-14
Estimated median emergence timing compared to different thermal regimes and time periods at locations in the Snake River. All thermal data sets used in the estimation, except the pre-HCC data, are from the time period 1996–2006. The pre-HCC time period estimation is based on thermal data from the time period 1954–1957.

The thermal shift created by Brownlee Reservoir also allows for slower cooling during the spring months and moderates summer maximum temperatures. Cooler spring temperatures likely also benefit SRFC salmon juveniles by creating a habitat less thermally suitable for predators of juvenile Chinook salmon, especially smallmouth bass. Smallmouth bass are non-native predators that forage more actively as water temperatures increase. Despite the cooler temperatures in the spring, SRFC salmon juveniles continue to display exceptional growth during their brief rearing period.

6.1.3.3. Fall Chinook Juvenile Outmigration

Today, early emergence has significant implications for SRFC salmon relative to outmigration survival. The sub-yearling SRFC salmon that begin moving downstream the first week of July (after flows begin to decline and downstream reservoirs warm) survive at rates of only 5 to 20%, whereas those that initiate movement earlier (in late May) survive at rates of 65 to 90% (Connor et al. 2003; Smith et al. 2003). Based on the estimated emergence timing using the pre-HCC thermal regime, outmigration would be significantly delayed and likely not initiated until later June or July when outmigration survival would be significantly reduced.

In the pre-HCC environment (before 1958, when Brownlee Reservoir was completed), there were no lower Snake River reservoirs or dams encountered by juvenile outmigrants, and it is possible that survival was much different relative to the outmigration timing observed today. However, as indicated by the pre-HCC thermal regime and even the Salmon River, water temperatures in July were relatively warm during this period and may have influenced the survival of late outmigrants. The pre-HCC thermal regime maximum summer temperatures were warmer than those observed today that are moderated as a result of the influence of the HCC. These pre-HCC lower river reaches may not have supported significant spawning because of poor over-summer survival associated with late emergence timing as observed today (Connor et al. 2003; Smith et al. 2003) with later outmigrants. This would be consistent with the likely reason that fall Chinook salmon spawning is not supported in the Salmon River—because there is no cool over-summer rearing habitat available.

6.1.3.4. Adult Migration

Adult SRFC salmon migrate from the ocean to spawning areas during late summer and early fall months. Anthropogenic changes have increased summer temperatures in the historic upstream habitats. Brownlee Reservoir generally moderates the peak summer temperatures in the outflow to Hells Canyon to be cooler than the inflow. This thermal benefit continues through about the middle of September, when the thermal shift starts to result in warmer temperatures than the inflow. Water temperatures are generally below 20°C when this thermal shift starts to be apparent.

The start of the SRFC salmon migration period for counting purposes in the Columbia River system has been identified as August 1 for observations at Bonneville Dam and August 18 for observations at Lower Granite Dam (Data Access in Real Time [DART] Adult Passage Reporting; cbr.washington.edu/dart/adult.html). Water temperatures throughout the lower Columbia River and Snake River, as well as the lower end of major tributaries, commonly exceed 20°C during this time. Concern relative to thermal regimes on adults relates primarily to adult migration periods, the potential of pre-spawn mortality, and potential effects to gamete viability. A temperature data set from 1954 to 1957 for the Central Ferry location (approximate location of present-day Lower Granite Dam) was used for comparative purposes to reflect conditions in the Lower Snake River before the construction of the HCC or any of the lower Snake River dams (Figure 6.1-15).

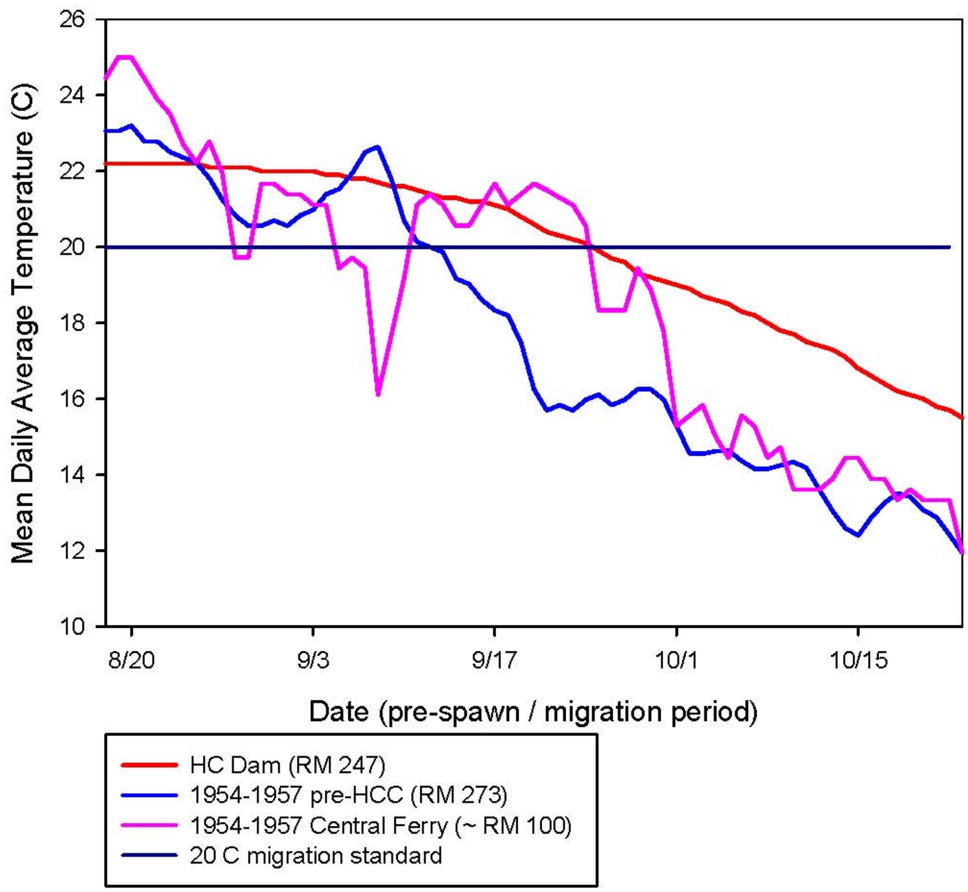

Figure 6.1-15
Mean daily average water temperatures that represent thermal patterns of the Snake River for the time period 1996–2006 at HCD (RM 247) and for the time period 1954–1957 for the pre-HCC location at RM 273 and RM 100 during August through mid-October.

In a pre-HCC thermal regime and in the lower Snake River (Central Ferry [approx. RM 100]), adult SRFC salmon would have experienced a similar period of exposure to temperatures elevated above 20°C between mid-August and mid-September as they do under the thermal regime present today below the HCC. However, early-arriving adults would experience a lower maximum temperature today than during the pre-HCC condition. Temperatures in all the thermal regimes examined, including present-day thermal regimes, would have dropped below the 20°C migration corridor standard by mid- to late-September.

There is no information as to how a pre-HCC thermal regime, Central Ferry thermal regime, or even the lower Columbia River thermal regime would have related to pre-spawn mortality or gamete viability. However, under the present-day HCC thermal regime, no evidence exists that pre-spawn mortality is different from that which occurs in other reaches (e.g., the Hanford reach). This is based on fish-to-redd ratios observed over the last 2 decades (Groves et al. 2007). Also, the operations of Dworshak Reservoir on the Clearwater River release cold water in the summer that substantially cools portions of Lower Granite Reservoir, creating thermal refugia in Lower Granite Reservoir and in the lower Clearwater River during the early pre-spawn environment. Therefore, thermal conditions prevalent in the Snake River today are cooler for pre-spawning adults than conditions prior to the construction of the HCC. In addition, the presence of natural thermal refugia throughout the adult migration may play a significant role in the migration and pre-spawn environments. Once fish migrate up the Snake River past the influence of the cold-water releases from Dworshak Reservoir, they enter a free-flowing environment. Unlike much of the impounded sections in the lower Columbia and Snake rivers, this free-flowing reach maintains much of the natural river processes that create thermal refugia. As discussed previously, this environment has a high connectivity to hyporheic habitats throughout its length to Hells Canyon. Locations of upwelling waters from the hyporheic environment likely provide thermal refuge, especially in areas associated with large gravel deposits and the many fluvial fans associated with the many perennial streams that enter the Snake River. These influences are difficult to measure or quantify but are likely significant in providing thermal refuge. In addition, there are several significant cold-water inflows to Hells Canyon, especially in the upper portion of this reach where high-elevation drainages from the Seven Devils Mountains enter the Snake River.

6.2. DO

Physical, chemical, and biological processes control the oxygen content of water. The solubility of DO decreases as water temperature increases, so changes in seasonal water temperatures substantially change the saturation level for DO. Reaeration, another physical process, tends to add DO to the water column when DO levels are low and release DO to the atmosphere when levels are above saturation. DO concentrations can also be affected by several biological processes related to elevated nutrient, organic matter, or algal levels. Nutrients promote algal growth that, in turn, generates oxygen during photosynthesis and consumes oxygen during respiration. Aerobic decomposition of dead algae, organic sediments, and other organic matter further depletes oxygen. Municipal, industrial, and agricultural wastes can also create a biochemical oxygen demand (BOD) as these wastes oxidize.

In the SR–HC TMDL, the IDEQ and ODEQ reported excessive TP concentrations in the Snake River upstream of the HCC (RM 409 to RM 335) and routinely observed nuisance algal growths in this reach and the upper end (riverine zone) of Brownlee Reservoir (IDEQ and ODEQ 2004). These findings corroborated those reported by Webb (1964) and Worth (1994). The IDEQ and ODEQ concluded from the data analysis that most phosphorus promoting the nuisance growths originated from sources upstream of the HCC (IDEQ and ODEQ 2004). Myers et al. (1998) and Hoelscher and Myers (2003) reported similar findings. The SR–HC TMDL linked nutrients and chlorophyll *a* with low DO levels downstream and set targets for both TP and algae for the attainment of DO criteria and the protection of beneficial uses (IDEQ and ODEQ 2004). They predicted that upstream reductions in TP loading, based on SR–HC TMDL allocations, would improve water quality in the Snake River and DO levels in Brownlee Reservoir. Specifically, low DO levels within the HCC are attributable to in-reservoir processing of inflow organic matter. The organic matter is a source of energy for the heterotrophic bacteria. Oxygen is consumed from the water when the heterotrophic bacteria decay the organic matter (Maier et al. 2000). An analysis has shown that upstream water-quality conditions influence water quality within and below the HCC, including oxygen demand and DO concentrations (Harrison et al. 1999; Myers et al. 2003). Substantial improvements to DO conditions in Brownlee Reservoir and downstream are anticipated following the attainment of the upstream TP and algae targets.
To address the remaining DO deficit relative to the aquatic life criterion in the HCC, a DO load

allocation of 1,125 tons of DO per year was established in the SR–HC TMDL for Brownlee Reservoir (IDEQ and ODEQ 2004). The SR-HC TMDL set the appropriate DO load allocation for IPC relative to degraded conditions in Brownlee Reservoir. Further, it identified the HCC 401 certification process as the mechanism for IPC to implement the load allocation.

The SR–HC TMDL did not evaluate nor establish any load allocations for DO below HCD. Beneficial uses below HCD include aquatic life and spawning (tables 5.1-1 and 5.1-2). Because downstream salmonid spawning uses have more stringent targets than those for which the upstream SR–HC TMDL targets were developed, the upstream allocations may not be adequate for downstream beneficial-use support. However, in the absence of a TMDL and resulting allocations, IPC has no defined DO load allocation to implement to ensure the continued operation of the HCC would not cause or contribute to an exceedance of downstream DO standards. In the sections that follow, IPC assessed the DO deficit downstream of Brownlee Reservoir under current conditions to quantify the effects of Oxbow and Hells Canyon reservoirs on current DO conditions within and downstream of the reservoirs. The analysis is conservative in that it assumes no improvements in upstream DO conditions that are expected to occur in the future with the upstream SR–HC TMDL implementation.

In addition to the analysis of current data, IPC has conducted modeling to estimate the DO conditions downstream of Brownlee Dam under full implementation of the SR-HC TMDL. While the analysis of measured data defines the effects of Oxbow and Hells Canyon reservoirs on current DO conditions, the modeling analysis illustrates that downstream DO standards should be met with implementation of the SR-HC TMDL. Some components of the SR-HC TMDL may have a protracted implementation schedule; however, IPC is proposing to mitigate the effects of the HCC upon issuance of the FERC license.

6.2.1. DO Standards

The application of DO standards applies to specified river reaches and times depending on the species present and life cycle needs. Oregon and Idaho both have standards specific to aquatic life and salmonid rearing and spawning (IDAPA 58.01.02.; OAR 340 041). Salmonid spawning standards further differentiate between water column and intergravel environments. The intergravel environments are essential, as eggs are deposited within gravels for development.

6.2.1.1. Brownlee, Oxbow and Hells Canyon Reservoirs

The IDEQ and ODEQ determined that 6.5 mg/L for water column dissolved oxygen was the appropriate and most stringent standard for the HCC reservoirs (IDEQ and ODEQ 2004). This was based on the resident fish community dominance of smallmouth bass, black crappie, and white crappie. The SR–HC TMDL target for the HCC is Oregon’s criterion of no less than 6.5 mg/L is applicable to waters dominated by cool water species such as smallmouth bass, and crappie (OAR 340-041-0016(3)). When the ODEQ determines, at its discretion, that adequate data exist, the DO may be no less than 6.5 mg/L as a 30-day average minimum, 5 mg/L as a 7-day minimum mean, and 4 mg/L as a daily minimum (Table 6.2-1). Idaho’s current DO criterion is no less than 6.0 mg/L, with allowances for specific strata in lakes and reservoirs to exhibit levels less than 6.0 mg/L (IDAPA 58.01.02.).

Table 6.2-1
State of Oregon DO criteria in the percent of saturation and mg/L for the protection of cool water aquatic life (OAR 340 041. n.d.)

Criteria	Aquatic Life (Cool Water)
Absolute minimum criteria[1]	6.5
Multiple criteria[2]	
Daily minimum	4.0
7-day minimum mean	5.0
30-day mean minimum	6.5

[1] Applicable criterion when data are limited
[2] Applicable criterion when adequate data exist at ODEQ discretion

6.2.1.2. Snake River Downstream of HCD

Salmonid spawning and migration corridor are designated uses of the Snake River downstream of the HCC. Salmonid spawning criteria apply to that portion of the Snake River below HCD (RM 247 to 188) from October 23 through April 15 for fall Chinook salmon and November 1 through March 30 for mountain whitefish. Because the Snake River downstream of Hells Canyon Dam is designated as a migration corridor, during periods outside of the salmonid spawning time period, the 6.5 mg/L dissolved oxygen Oregon standard applies and is a more stringent criterion than Idaho’s 6.0 mg/L general criterion.

Oregon and Idaho have salmonid-spawning standards for water column and intergravel environments. Oregon’s water-column DO criteria are no less than 11 mg/L; however, if the minimum intergravel DO, measured as a spatial median, is 8 mg/L or greater, the water-column DO criterion can be a minimum of 9 mg/L (OAR 340-041-0016(1)(a)). Where conditions of barometric pressure, altitude, and temperature preclude the attainment of the 11-mg/L or 9-mg/L criteria, the DO may be no less than 95% of saturation (OAR 340-041-0016(1)(b)). The spatial median intergravel DO criterion is no less than 8 mg/L (OAR 340-041-0016(1)(c)). Idaho’s general water-column criterion is no less than 6 mg/L or 90% of saturation (IDAPA 58.01.02.250.f.i.2.a.). The intergravel criteria are no less than 5 mg/L as an absolute minimum and no less than 6 mg/L as a 7-day average mean (IDAPA 58.01.02.250.f.i.1.). The Oregon standards are more stringent and are used in the following analysis.

Intergravel DO concentrations are important to support salmonid spawning. While water-column DO is often relied on as an indicator of suitable salmonid-spawning habitat, concentrations of intergravel DO directly affect egg survival in salmonid redds (Alderice et al. 1958; Cobel 1961; Maret et al. 1993). The Oregon salmonid-spawning standards for water-column levels are designed to attain intergravel levels of 8 mg/L. Therefore, the water-column criterion of 11 mg/L assumes a differential (i.e., water-column DO minus intergravel DO) of 3 mg/L. There is a sufficient amount of water-column and intergravel DO data for the Snake River below the HCC to determine a water-column DO level that would result in meeting the intergravel criterion of 8 mg/L based on measured differentials. This type of evaluation is consistent with the approach used for the Oregon standard that allows water-column levels of 9 mg/L, provided intergravel levels are no less than 8 mg/L.

Water-column and intergravel DO measurements have been collected by IPC biologists as part of a study to evaluate the incubation survival of fall Chinook salmon above and below the HCC (Hanrahan et al. 2007; Groves and Chandler 2005; Hanrahan et al. 2005; P. Groves, IPC, unpubl. data). As part of this study, DO measurements in the water column, artificial redds, and ambient hyporheic zone were collected approximately every 2 weeks throughout the 2003/2004 and 2004/2005 spawning seasons. In 2003/2004, 8 sites were sampled below HCD (5 above the confluence of the Salmon River and 3 below). In 2004/2005, 6 sites were sampled (4 above the confluence of the Salmon River and 2 below). Sample sites were located at observed spawning areas below HCD (Figure 6.2-1). At each site, a cluster of 3 artificial redds was constructed. Artificial redd locations at each site were chosen at random. The locations exhibited the habitat-use criteria described for fall Chinook salmon within the Snake River (Groves and Chandler 1999). Artificial redds were constructed in shallow water (approximately 0.6-meters [m] deep), where water velocities averaged 0.7 meters per second (m/s), to facilitate construction and ensure personnel safety.

Artificial redds were constructed using a shovel to lift and toss substrate downstream. This activity mimics the action of a salmon digging (Chapman 1988) and helps winnow fines from the gravels (based on methods described by Burton et al. 1990; McHenry et al. 1994; and Clayton et al. 1996). A characteristic depression (approximately 1 meter [m] in diameter) and “tailspill” is constructed using this technique. An intergravel sampling tube or an intergravel sampling tube and egg basket were placed within each artificial redd. The egg basket was buried approximately 20 centimeters (cm) deep (measured from the top surface of the basket to the surface of the substrate). Therefore, the eggs were approximately 20 to 35 cm below the gravel’s surface within a hyporheic stratum. This depth is similar to that of a fall Chinook salmon egg pocket 18 to 43 cm below the substrate surface (Chapman et al. 1986; Chapman 1988).

Figure 6.2-1
Map showing locations of artificial redds and water-column sampling sites on the Snake River from the Salmon River confluence upstream to King Hill

Periodic intergravel water samples representative of conditions surrounding the developing embryos were collected through an intergravel sampling tube. Intergravel DO was measured using a peristaltic pump and a flow cell on a Hydrolab® Minisonde Multiprobe maintained and calibrated per the manufacturer's specifications. IPC evaluated DO concentrations and egg survival in 3 types of artificial redds over 2 spawning seasons. The following were the 3 types of artificial redds:

1. **Empty redds** are artificial redds that contained only an intergravel sampling tube. Empty redds were constructed during the last 2 weeks of October (early spawning period).

2. **Green-egg redds** are artificial redds and egg baskets that contained “green” eggs. Green-egg redds were constructed during the first week of November (peak spawning period).

3. **Eyed-egg redds** are artificial redds and egg baskets that contained “eyed” eggs. Eyed-egg redds were constructed during the first week of December (end of the spawning period).

Intergravel DO concentrations measured in artificial redds below the HCC were generally very similar to water-column measurements made at the same time (figures 6.2-2, 6.2-3, and 6.2-4). With respect to permeability and transport capability, the substrate quality within the Hells Canyon reach of the Snake River was relatively high when compared to other regional samples and literature values (Arntzen et al. 2001). Therefore, when intergravel DO was low below the HCC, it was a result of low water-column DO levels. This illustrates the correlation between the intergravel and water-column DO below the HCC related to high permeability and other water-quality characteristics. A relatively small difference is consistently seen between water-column and intergravel DO; as water-column DO increases below the HCC, intergravel DO also increases. As discussed in following sections, this correlation does not always exist. In some locations, such as upstream of Brownlee Reservoir, plugging of the artificial redd interstices and biological processes in the gravels over the life of a redd strongly controls intergravel DO levels (Groves and Chandler 2005). In these situations, water-column DO can be high and increasing while intergravel DO in an artificial redd can be low and decreasing.

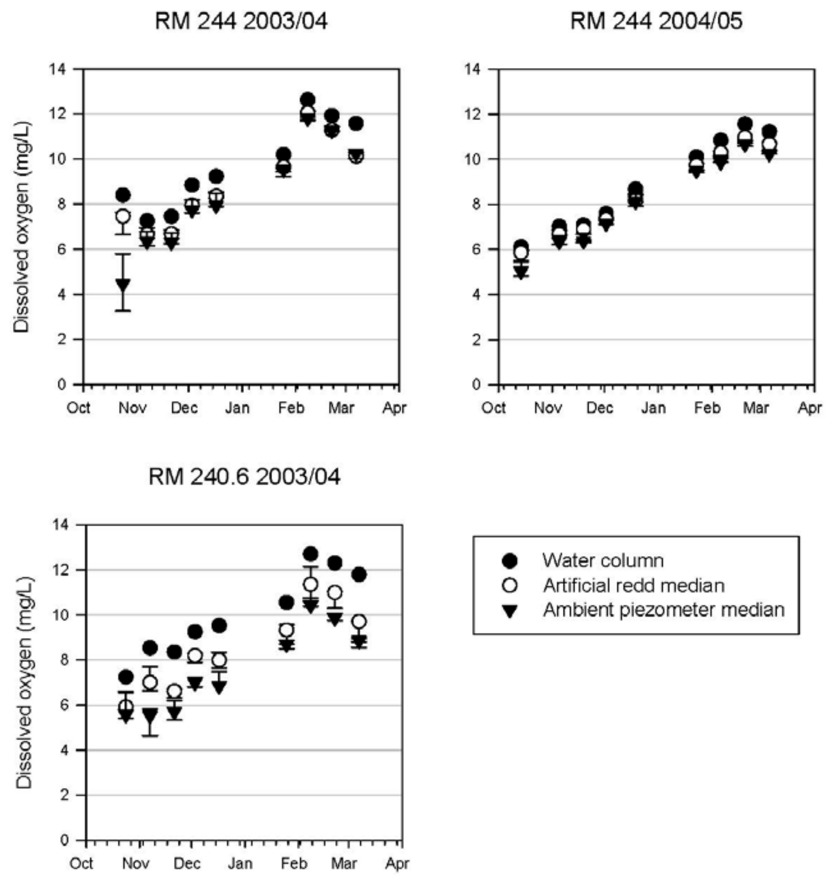

Figure 6.2-2
Intergravel DO in mg/L at sites downstream of HCD with no eggs in the 2003/2004 and 2004/2005 seasons. Symbols show the median of 3 artificial redds or ambient piezometers, while error bars show the minimum and maximum values.

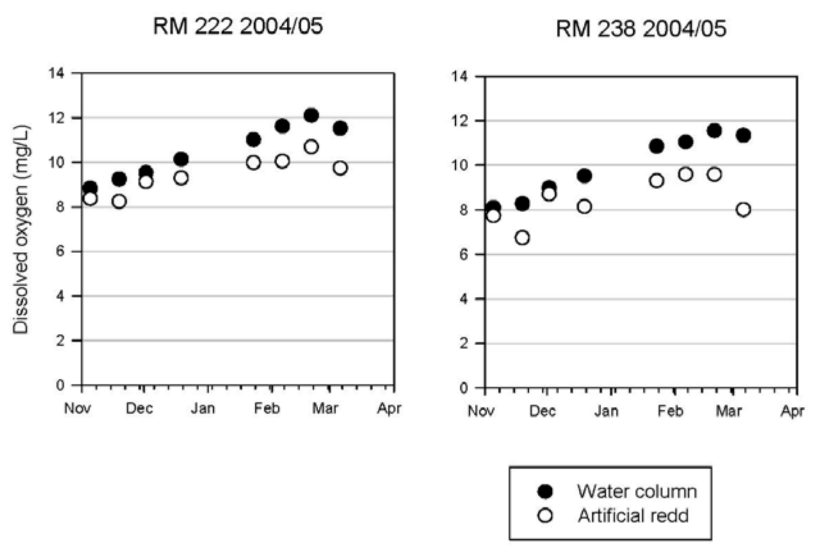

Figure 6.2-3
Intergravel DO in mg/L concentrations at sites downstream of HCD with green eggs in the 2004/2005 season

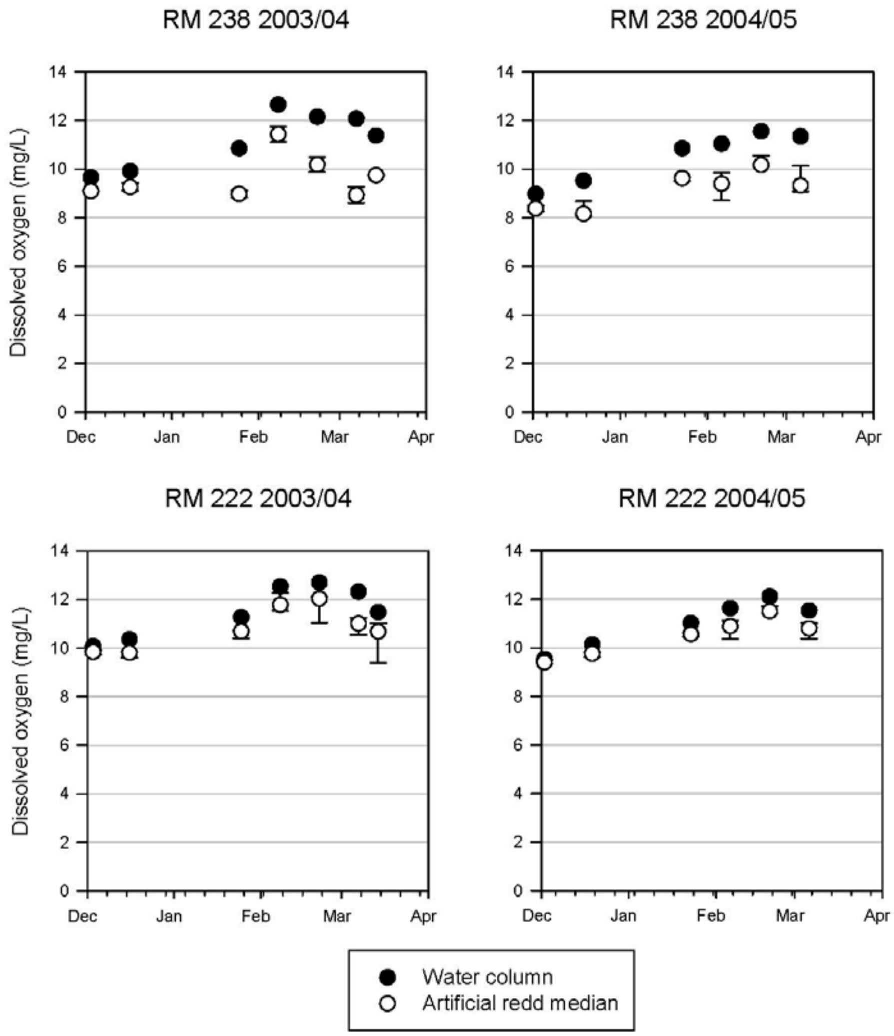

Figure 6.2-4
Intergravel DO in mg/L at sites downstream of HCD with eyed eggs in the 2003/2004 and 2004/2005 seasons. Symbols show the median of 3 artificial redds, while error bars show the minimum and maximum values.

Intergravel and water-column DO measurements collected below the HCC were used to calculate a water-column DO level that would support the 8 mg/L Oregon intergravel criteria. A DO differential was calculated for each sample event by subtracting the intergravel DO (from each artificial redd) from the water-column DO (measured at the same time at each site). The summarized differentials from the artificial redds above the Salmon River confluence were generally less than 3 mg/L, with 90% of all the differentials less than 2 mg/L 8 weeks following redd construction (Table 6.2-2). Not all artificial redds were constructed on the same date; therefore, differentials are summarized by sample timing following construction (i.e., the first date is immediately after construction, and the second date is 2 weeks later). Sampling occurred approximately every 2 weeks. The differentials generally increased over time due to processes affecting intergravel DO levels after redd construction, such as the plugging of gravels by organic and inorganic materials.

Table 6.2-2
Summarized DO differentials in mg/L between intergravel DO measured in artificially constructed redds and DO in the water column for sites on the Snake River below HCD and above the Salmon River confluence. The time period between subsequent dates is approximately 2 weeks.

Upper Hells Canyon	First Date	Second Date	Third Date	Fourth Date	Fifth Date	Sixth Date	Seventh Date	Eighth Date	Ninth Date
Minimum	0.0	0.1	0.2	0.2	0.3	0.3	0.5	0.5	0.5
10th percentile	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.6	0.5
25th percentile	0.4	0.4	0.5	0.7	0.7	0.8	0.6	0.7	0.9
Median	0.5	0.7	0.8	0.9	1.0	1.3	1.2	1.3	1.5
75th percentile	0.6	0.8	1.3	1.3	1.5	1.8	1.6	1.8	2.1
90th percentile	1.3	1.5	1.7	1.6	1.7	2.3	2.0	2.1	2.3
Maximum	1.8	2.0	2.0	2.9	2.3	3.5	2.1	3.3	3.0
N	30.0	30.0	30.0	30.0	30.0	30.0	21.0	15.0	9.0

Note: Summary includes 2003/2004 and 2004/2005 datasets for below the HCC and above the confluence with the Salmon River.

Oregon's standards reference a spatial-median intergravel DO level. To compare the differentials summarized in Table 6.2-2 to the Oregon standard, the median differential of each site (i.e., a cluster of 3 artificial redds) was calculated. This median value, when added to the intergravel DO criterion of 8 mg/L, represents a water-column DO target that would result in meeting the spatial-median intergravel criterion at that site. The maximum median differentials were below 2 mg/L and changed through the season (Table 6.2-3). The 90th percentile of these median differentials was selected as a level appropriate to apply in determining a water-column criterion. The first 5 sample dates were used, and the value on the fifth date carried through the remainder of the salmonid spawning period. The first 5 sample dates represent 10 weeks into the spawning period (October 23–January 1), after which measured data below the HCC show criteria are met (see Section 6.2.2.1.5. Outflow DO). The resulting water-column criteria ranged from 9.1 mg/L on October 23 to 9.6 mg/L through the end of the season (Table 6.2-4). These water-column criteria were applied to the Snake River below HCD from October 23 through April 15 in all following analyses relative to the HCC outflow DO.

Table 6.2-3
Summarized site median DO differentials in mg/L between intergravel DO measured in artificially constructed redds and DO in the water column for sites on the Snake River below HCD and above the Salmon River confluence. The time between subsequent dates is approximately 2 weeks.

Upper Hells Canyon	First Date	Second Date	Third Date	Fourth Date	Fifth Date
Minimum	0.2	0.2	0.2	0.3	0.5
10th percentile	0.2	0.3	0.2	0.6	0.6
25th percentile	0.3	0.4	0.4	0.8	0.7
Median	0.5	0.6	0.9	0.9	0.9
75th percentile	0.6	0.8	1.2	1.1	1.5
90th percentile	1.1	1.5	1.7	1.5	1.6
Maximum	1.7	1.5	1.7	1.5	1.7
N	9.0	9.0	9.0	9.0	9.0

Note: Summary includes 2003/2004 and 2004/2005 datasets for below HCD and above the confluence with the Salmon River.

Table 6.2-4
Water-column DO criteria in mg/L calculated from the 90th percentile of the summarized site median DO differentials. Dates are 2-week increments during the salmonid spawning season when criteria apply.

	First Date (10/23)	Second Date (11/7)	Third Date (11/22)	Fourth Date (12/7)	Fifth Date (12/21–4/15)
Water-column DO criteria (mg/L)	9.1	9.5	9.7	9.5	9.6

6.2.2. Conditions Relative to DO

The following discussion assesses DO conditions relative to either the 6.5 mg/L criterion, or the water column criteria necessary to maintain 8.0 mg/L intergravel conditions during salmonid spawning (Table 6.2-4).

6.2.2.1. Current Conditions

6.2.2.1.1. Water-Column Conditions Upstream of the HCC

DO conditions in the Snake River flowing into Brownlee Reservoir typically fall below criteria for a short time in mid-summer (Figure 6.2-5). The relatively high DO at Brownlee inflow is related to reaeration processes of a shallow, flowing river and elevated primary productivity from both suspended algae and rooted aquatic macrophytes (IDEQ and ODEQ 2004). As a result of high productivity, inflow DO levels are supersaturated throughout much of the year, and DO can cycle on a diel period from 2 to more than 3 mg/L (Figure 6.2-6). This is most obvious during spring and early summer when suspended algae levels are at the peak.

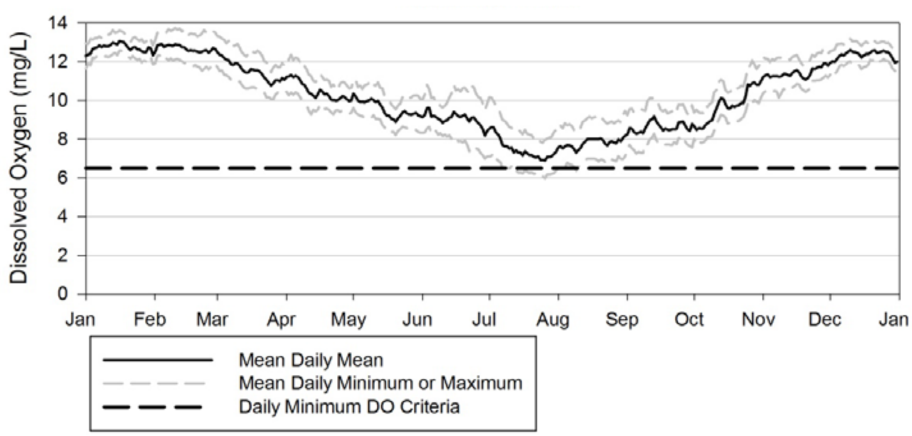

Figure 6.2-5
Snake River Brownlee Reservoir inflow mean daily mean, mean daily minimum, and mean daily maximum DO in mg/L summarized from measurements made approximately every 10 minutes over the 2002 through 2012 period. Also shown is the SR–HC TMDL absolute minimum DO criterion of 6.5 mg/L for the support of cold-water aquatic life.

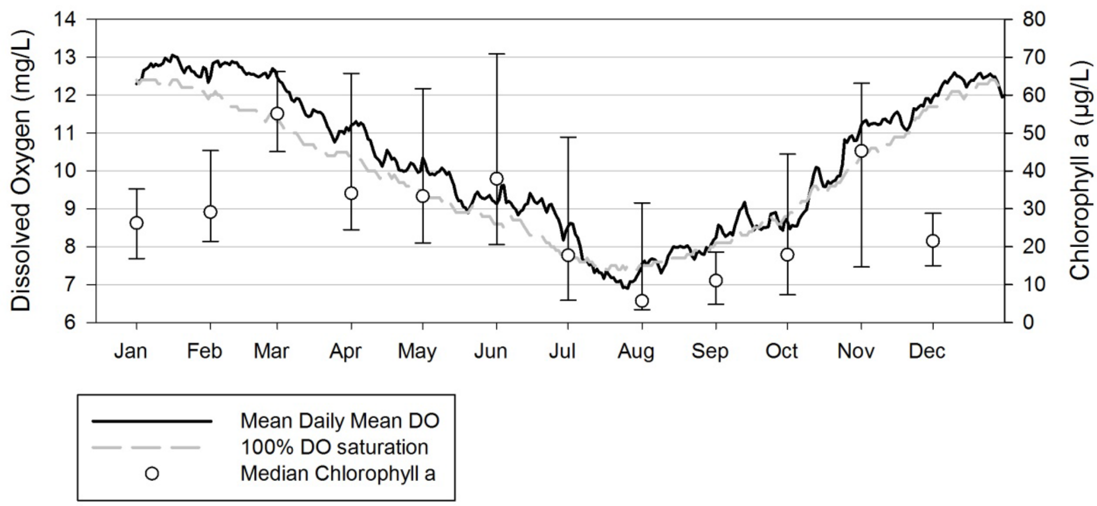

Figure 6.2-6
Snake River Brownlee Reservoir inflow mean daily mean DO and calculated 100% saturation levels of DO in mg/L based on the mean daily mean temperature. Both are summarized from measurements made approximately every 10 minutes over the 2002 through 2012 period. Also shown are median (circles) monthly chlorophyll *a* in µg/L levels from samples every 2 weeks during the same time. Upper and lower error bars shows the 25^{th} and 75^{th} percentiles of the chlorophyll *a* data.

Elevated primary productivity in the Snake River reach upstream of Brownlee Reservoir was the primary focus of the SR–HC TMDL, and a reduction in primary productivity was sought through the development of the TP target (IDEQ and ODEQ 2004). Elevated primary productivity has noticeable impacts to DO conditions flowing into Brownlee Reservoir, DO conditions in Brownlee Reservoir and the HCC due to the settling and decay of large loads of algae and suspended organic material, and intergravel DO conditions upstream of the HCC. IPC studied water quality and intergravel conditions in the Snake River upstream of the HCC relative to the support of salmonid spawning. Water-column data collected from March 2002 through April 2003 at 7 sites along the Snake River from King Hill (RM 546), Idaho, to below HCD (Harrison 2005) provides a broad perspective of water-quality parameters related to particulate material and longitudinal changes through the Snake River (Table 6.2-5, Figure 6.2-7).

Table 6.2-5
Selected parameters collected in 2002 and 2003 as part of a Snake River organic-matter study

Parameter	Units	Sample Size	Description
Chlorophyll *a*	µg/L	22–24	Indicator of algal biomass.
Total organic carbon (TOC)	mg/L	22–24	Total carbon concentration per liter of sample.
Dissolved organic carbon (DOC)	mg/L	22–24	Total carbon concentration per liter of filtered (0.45-micrometers [µm]) sample.
Particulate organic carbon (POC) (POC = TOC – DOC)	mg/L	22–24	TOC minus DOC. The amount of carbon per liter that is retained on the 0.45-µm filter.
TSS	mg/L	22–24	Dry weight of material retained on a filter.
Volatile suspended solids (VSS)	mg/L	22–24	Weight of TSS material that will combust at 550°C.
5-day and 30-day BOD (BOD5, BOD30)	mg/L	13–16	Oxygen consumed per liter in 5 or 30 days.
5-day and 30-day dissolved BOD (dissolved biochemical oxygen demand [DBOD]5, DBOD30)	mg/L	13–16	Oxygen consumed per liter of filtered sample in 5 or 30 days.
5-day and 30-day particulate BOD (particulate biochemical oxygen demand [PBOD]5, PBOD30) (equals BOD – DBOD)	mg/L	13–16	BOD minus dissolved BOD. The amount of oxygen consumed in 5 or 30 days that is attributable to the material retained on the 0.45-µm filter.
Chemical oxygen demand (COD)	mg/L	22–24	Oxygen consumed per liter following the complete oxidation of the sample with a strong oxidizing agent.
Bacteria (heterotropic plate counts)	#/100 ml	13–16	Number of colony-forming units (CFU) per 100 ml of sample.
Bacteria secondary production (BSP)	µg carbon/L/hour (hr)	13–16	Rate of carbon incorporation due to bacterial secondary production.
TP	mg/L	22–24	TP per liter sample.
Orthophosphate (OP)	mg/L	22–24	Dissolved OP per liter sample.
Particulate phosphorus (PP)	mg/L	22–24	TP – OP; the amount of phosphorus retained on the filter

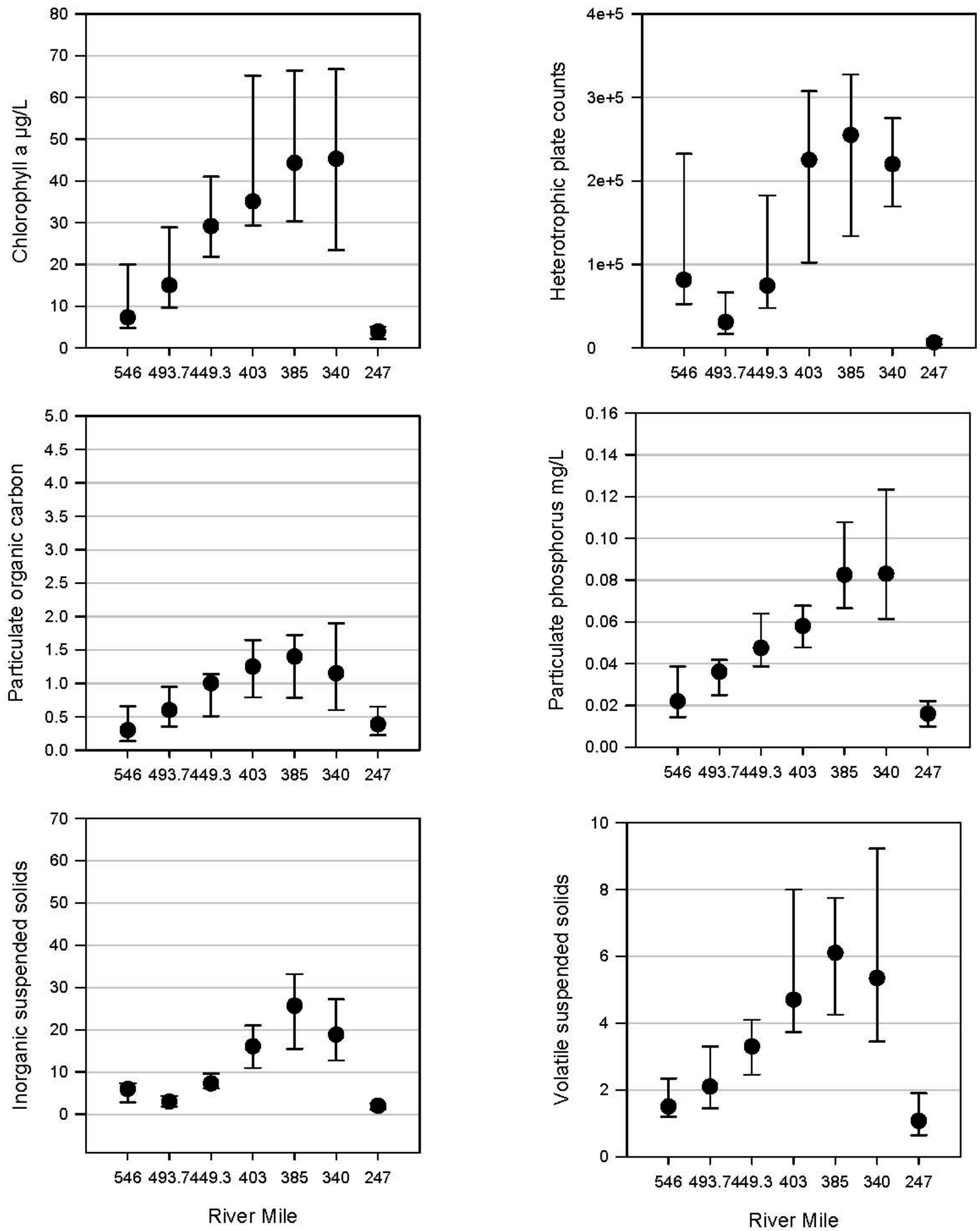

Figure 6.2-7
Water-column concentrations of particulate material at 7 sites in the Snake River. Dots showing medians and error bars are the 75th and 25th percentiles of data collected from March 2002 through April 2003.

Algal levels change considerably from King Hill to below the HCC. Figure 6.2-7 shows algal levels, as indicated by chlorophyll *a*, were approximately 10 µg/L near King Hill (RM 546) and increased to approximately 45 µg/L at Brownlee Reservoir inflow (RM 340). These increases were followed by substantial decreases to less than 10 µg/L in the HCC outflow (RM 247). Levels of particulate organic material (including algae) and inorganic sediment also increased from King Hill to the Brownlee Reservoir inflow. Similar trends were also reported in the Snake River by the IDEQ (Worth 1994). Substantial decreases again occurred through the HCC (Figure 6.2-7). The levels of particulate material released from the HCC were 67 to 97% less than Brownlee Reservoir inflow levels (Table 6.2-6). The highest reduction observed, 97%, was for heterotrophic bacteria. Bacterial secondary production, algae (i.e., chlorophyll *a*), and PP were all reduced by more than 80%. POC showed the lowest reduction at 67%. These changes through the HCC are indicative of the settling of particulate material in Brownlee Reservoir. The organic material that settles in Brownlee Reservoir decays, and this process consumes oxygen, contributing to the current low DO levels in Brownlee Reservoir (see Section 6.2.2.1.4. Reservoir DO).

Dissolved constituents decreased less compared to particulate constituents through the HCC, ranging from 6% for DOC to 36% for dissolved 5-day BOD (Table 6.2-6). The higher level of reduction for the dissolved 5-day BOD suggests a shift in the nature of DOC, with more refractory material being released downstream of the HCC. Dissolved inorganic phosphorus and nitrogen levels increased while total nutrient levels decreased by 29 and 45%, respectively.

These water-column data showed relatively low levels of particulate organic matter and inorganic sediment released from the HCC compared to levels upstream. As discussed below, these differences are directly related to DO conditions in Brownlee Reservoir and differences in intergravel conditions upstream and downstream of the HCC.

Table 6.2-6
Medians (ranges) and the percent of reduction (based on medians) for particulate, dissolved, and total constituents at Brownlee inflow (RM 340) and Hells Canyon outflow (RM 247) from March to October 2002 (n = 13–14) or March 2002 to April 2003 (n = 22–24)

	Brownlee Inflow RM 340	**Hells Canyon Outflow RM 247**	**Percent of Reduction**	***N***
Particulate				
Chlorophyll *a* µg/L	45.28	3.93	91%	23
	(8.22–114.21)	(0.44–22.49)		
Heterotrophic plate counts CFU/100 ml	220,000	6,650	97%	14
	(3,900–670,000)	(1,600–270,000)		
POC mg/L	1.15	0.39	67%	24
	(0.2–3.6)	(0.08–0.98)		
PP mg/L	0.083	0.016	81%	24
	(0.026–0.145)	(<0.005–0.059)		
TSS mg/L	24.3	3.2	87%	22
	(4.3–72.9)	(0.8–38.0)		
VSS mg/L	5.4	1.1	80%	22
Inorganic suspended solids mg/L	18.9	1.9	90%	22
	(3.0–61.7)	(0.5–35.8)		

Table 6.2-6 (continued)

	Brownlee Inflow RM 340	Hells Canyon Outflow RM 247	Percent of Reduction	*N*
PBOD 5-day mg/L	1.9	0.5	74%	13
	(1.1–5.5)	(0.2–1.0)		
PBOD 30-day mg/L	4.7	0.9	81%	13
	(2.3–7.4)	(0.2–2.8)		
Bacterial production µg carbon/L/hr	0.93	0.12	87%	14
	(0.31–2.20)	(0.0–0.25)		
Dissolved				
DOC mg/L	2.75	2.58	6%	24
	(1.62–3.80)	(1.82–3.2)		
Orthophosphate mg/L	0.027	0.060	–123%	24
	(0.006–0.072)	(0.036–0.105)		
Nitrate mg/L as N	0.63	0.74	–19%	24
	(0.13–1.71)	(0.25–1.74)		
Ammonia mg/L as N	0.01	0.06	–450%	24
	(<0.01–0.11)	(<0.01–0.19)		
DBOD 5-day mg/L	1.1	0.7	36%	13
	(0.5–2.7)	(0.5–1.3)		
DBOD 30-day mg/L	3.3	2.2	33%	13
	(1.6–5.8)	(1.4–3.5)		
Total				
TOC mg/L	4.14	3.10	25%	24
	(1.98–7.4)	(2.02–4.0)		
TP mg/L	0.115	0.081	29%	24
	(0.054–0.195)	(0.052–0.115)		
Total nitrogen mg/L	1.33	1.24	45%	24
	(1.03–2.23)	(0.63–2.14)		
BOD 5-day mg/L	3.7	1.2	68%	13
	(2.4–7.1)	(0.7–2.1)		
BOD 30-day mg/L	8.1	3.2	60%	13
	(6.9–10.4)	(1.4–3.5)		
COD mg/L	16	10	38%	22
	(5–29)	(<3–15)		

6.2.2.1.2. Intergravel Conditions Upstream of the HCC

Intergravel DO conditions upstream of the HCC were in sharp contrast to conditions measured downstream of the HCC. Water-column DO concentrations and intergravel DO concentrations measured in artificial redds below the HCC (see Section 6.2.1.1. Aquatic Life and Salmonid Rearing) were both below criteria at the initiation of the fall Chinook salmon spawning season and increased as the season progressed and the embryos developed (figures 6.2-2, 6.2-3, and 6.2-4). Counter to this, at sites sampled by IPC in 2003/2004 and 2004/2005 above the HCC (Figure 6.2-1), intergravel DO concentrations measured in artificial redds were generally below criteria, even though water-column DO levels often met criteria (figures 6.2-8, 6.2-9, and 6.2-10). Similar data collected during the 1999/2000 and 2000/2001 seasons by Groves and Chandler (2005) at these same sites (and others) showed that intergravel DO in artificial redds dropped below 8 mg/L at sites above the HCC (near 2 mg/L at some sites). DO levels in the undisturbed ambient gravels (i.e., adjacent gravels not disturbed by the construction of artificial redds) above the HCC were generally less than 2 mg/L through the whole season (Figure 6.2-8).

Unlike locations below the HCC, most locations above the HCC had higher intergravel DO in the beginning, shortly after artificial redd construction, and concentrations declined thereafter. Median intergravel DO levels dropped below 8 mg/L in artificial redds constructed near the Brownlee Reservoir inflow (RM 345) and near the city of Glenns Ferry, Idaho (Figure 6.2-8). Median intergravel DO levels also declined following artificial redd construction in the Swan Falls reach;[28] however, initial concentrations were less than 8 mg/L (figures 6.2-9 and 6.2-10).

Differences in ambient gravel characteristics do not explain the differences in intergravel DO. Using freeze core and hydraulic slug test techniques, Hanrahan et al. (2005) examined ambient gravel characteristics at 2 historic spawning locations in the Swan Falls reach and showed that hydraulic conductivity in gravel at the Swan Falls sites was comparable to rates measured in spawning gravel in the Hells Canyon reach of the Snake River and the Hanford reach of the Columbia River. Using a temperature-modeling approach showed that velocities in the artificial redds in the Hells Canyon reach reduced from initial levels immediately after construction but remained relatively high through the spawning season (Hanrahan et al. 2007). Similar analysis above the HCC showed the construction of an artificial redd dramatically increased intergravel velocities from velocities in ambient gravels. However, following artificial redd construction, intergravel velocities rapidly decreased.

In addition to intergravel DO measurements from the artificial redds, fertilized fall Chinook eggs were incubated in egg baskets in some of the artificial redds constructed in the Swan Falls reach. The baskets were retrieved just prior to calculated emergence based on degree days and survival (among other variables) recorded. Overall survival in the Swan Falls reach was very poor in both seasons (Table 6.2-7). The middle site in the Swan Falls reach showed the highest survival, although no survival was seen for green eggs at this site (Table 6.2-7).

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[28] The sites in this reach are the same sites sampled in 1999/2000 and 2000/2001 and reported in Groves and Chandler (2005).

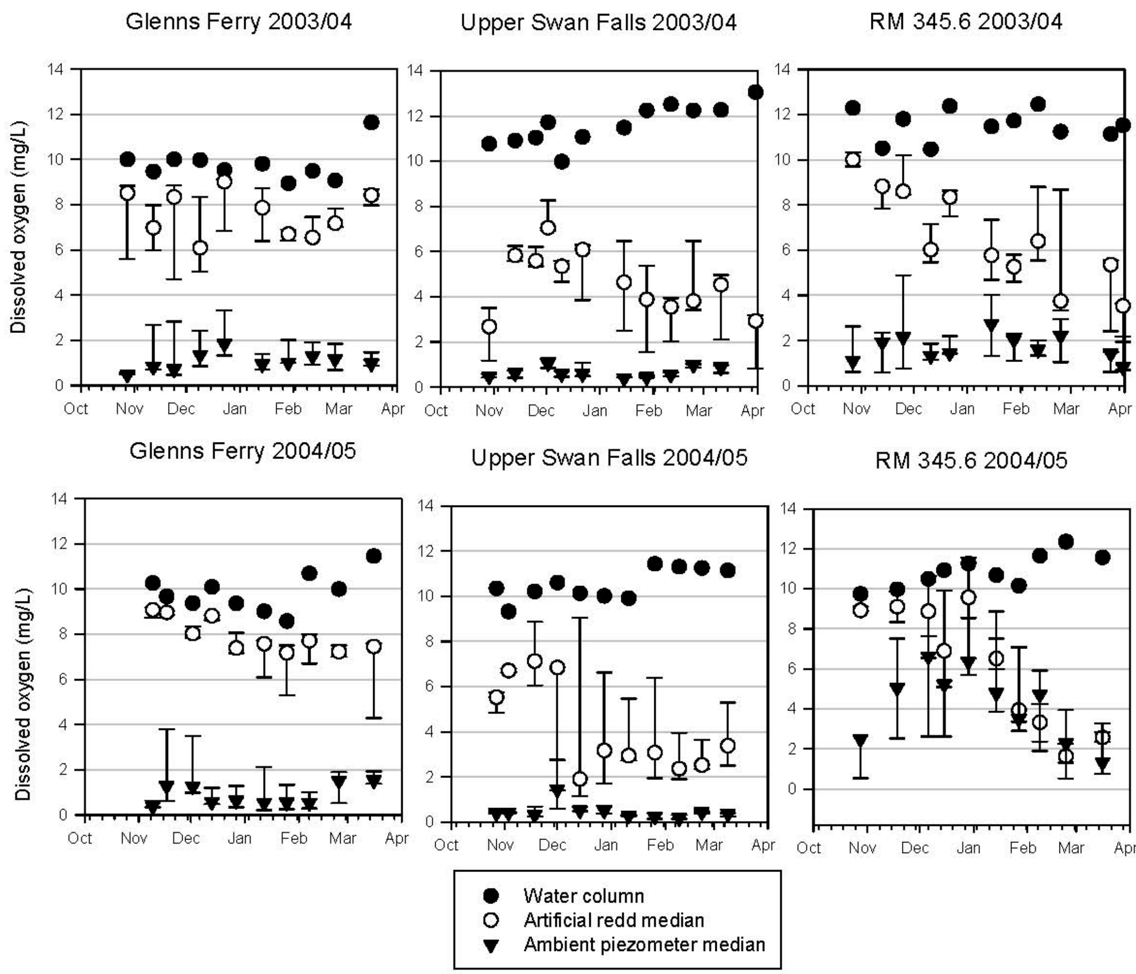


Figure 6.2-8
Intergravel DO in mg/L at sites upstream of Brownlee Reservoir with no eggs in the 2003/2004 and 2004/2005 seasons. Symbols show the median of 3 artificial redds or ambient piezometers, while error bars show the minimum and maximum values.

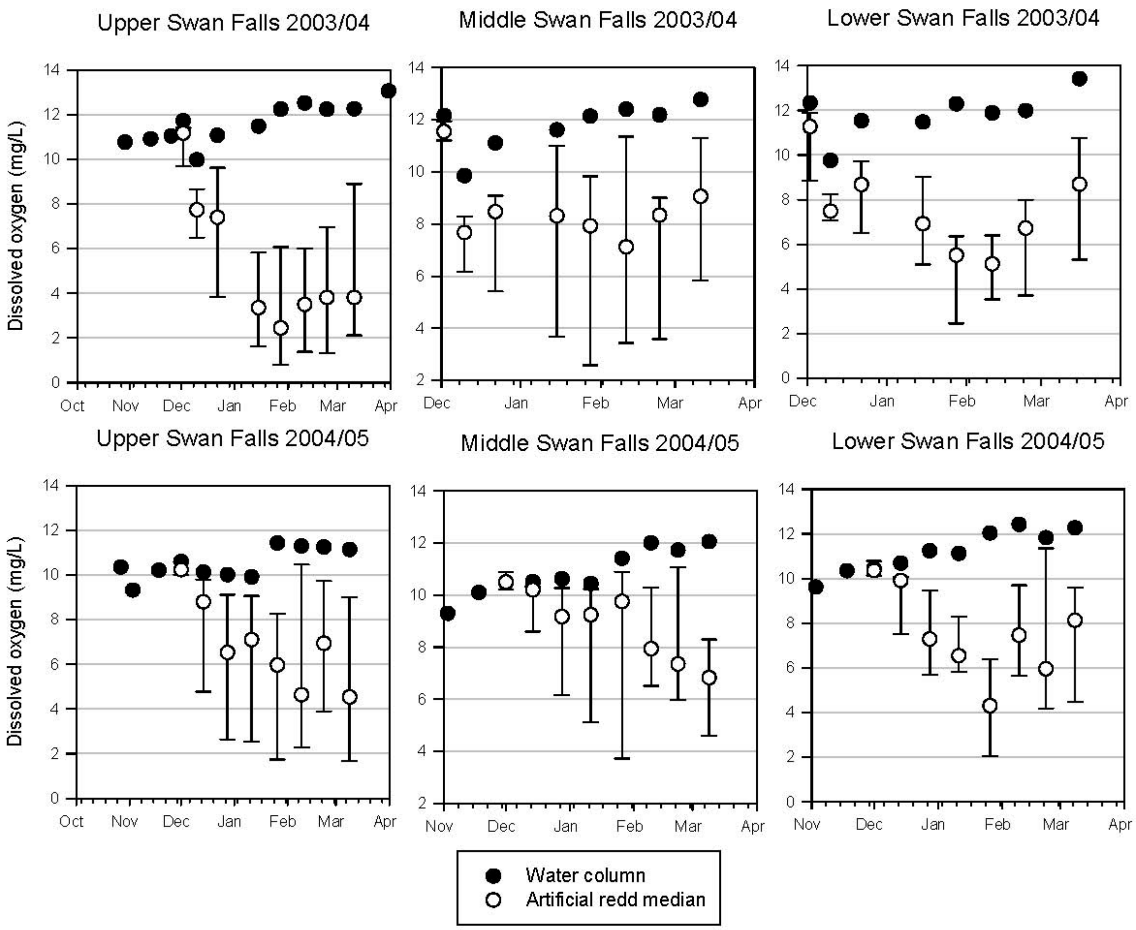


Figure 6.2-9
Intergravel DO in mg/L at sites upstream of Brownlee Reservoir with eyed eggs in the 2003/2004 and 2004/2005 seasons. Symbols show the median of 9 (2003/2004) or 7 (2004/2005) artificial redds, while error bars show the minimum and maximum values.

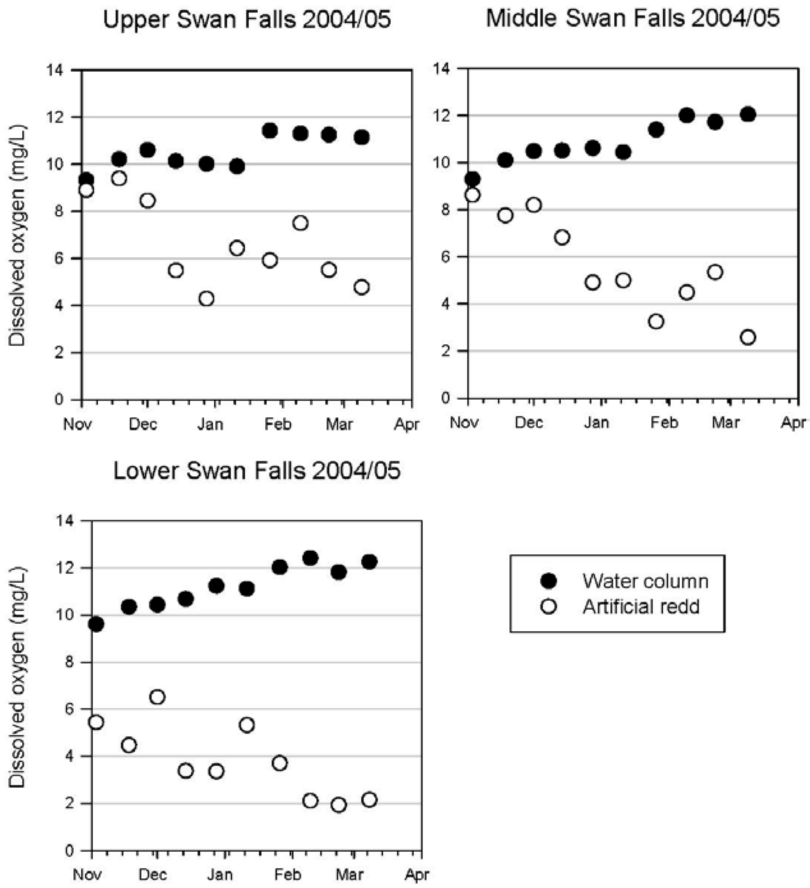


Figure 6.2-10
Intergravel DO in mg/L at sites upstream of Brownlee Reservoir with green eggs in the 2004/2005 season

Table 6.2-7
Survival of fall Chinook salmon eggs placed in artificial redds above and below the HCC for the 2003/2004 and 2004/2005 seasons

Study Year and Location	Average Survival for Eyed Eggs	Average Survival for Green Eggs	No. of Egg Baskets	Total No. of Eyed Eggs	Total No. of Green Eggs
2003/2004					
Swan Falls overall	0.23	–	27	2,700	–
Upper Swan Falls	0.00	–	9	900	–
Middle Swan Falls	0.68	–	9	900	–
Lower Swan Falls	0.00	–	9	900	–
Downstream of HCC overall	0.83	–	18	1,800	–
2004/2005					
Swan Falls overall	0.17	0.00	28 eyed, 4 green	2,800	600
Upper Swan Falls	0.12	0.00	7 eyed, 1 green	700	150
Middle Swan Falls	0.42	0.00	7 eyed, 1 green	700	150
Lower Swan Falls	0.00	0.00	7 eyed, 1 green	700	150
Lower Swan Falls	0.02	0.00	7 eyed, 1 green	700	150
Downstream of HCC overall	0.79	0.55	18 eyed, 6 green	1,800	900

6.2.2.1.3. Interconnection between Water-Column and Intergravel Conditions

Oregon's salmonid-spawning water-column DO criteria require levels designed to ensure intergravel DO levels of 8 mg/L are attained. Water-column and intergravel DO data collected below the HCC show a strong correlation between water-column DO and intergravel DO suggesting that maintaining water-column levels at sufficient levels assists in maintaining intergravel DO criteria. However, Snake River data collected above the HCC show that high water-column DO levels (e.g., at or above saturation) do not always result in intergravel DO levels that meet the criterion. The following are factors that affect intergravel DO concentrations:

- Exchange rate between surface and subsurface waters
- Residence time of water in the subsurface
- Processing of nutrients (including organic matter, nitrogen, and phosphorus) in the hyporheic zone

Two dominant factors controlling nutrient processing in the hyporheic zone are 1) surface to subsurface water-exchange rate and 2) residence time of water within gravels (Findlay 1995; Mulholland and DeAngelis 2000). Physical plugging of gravels by inorganic and organic (detrital) matter is one of the many processes that reduces water exchange rates and leads to increased residence times. Physical plugging occurs as water-column particulate matter infiltrates gravel either through settling or from surrounding surface-water velocities. During high-water events, these materials can also become mixed with gravels as streambeds are eroded and redeposited. It is likely that low intergravel DO levels are related to the reduction in intergravel velocities in artificial redds due to physical plugging of gravels (Hanrahan et al. 2007). Water-column sampling showed that higher levels of particulate matter occurred upstream of the HCC (Figure 6.2-7) and is likely a reason intergravel DO levels decreased after the initial artificial redd construction.

Plugging can also be caused by the production of either periphyton on the substrate surface or biofilm within the gravels (Battin and Sengschmitt 1999). Biofilms are primarily layers formed by bacteria on substrate surfaces. Bacteria secrete extracellular polysaccharides (glycocalyx) that form a visible slime layer and provide a matrix for building the "biofilm community" (Marshall 1997). Periphyton, which forms in the polysaccharide matrix produced by bacteria, is generally considered to be autotrophic algae (Welch and Lindell 1996). However, heterotrophic bacteria and fungi can dominate if there is a source of dissolved organic matter or if light is restricted. Extensive areas of periphyton, which can include protozoa and insects, have been observed by IPC biologists in the Snake River above the HCC. Additionally, the formation of heterotrophic biofilm within gravels is likely, considering the relatively high organic-matter levels and heterotrophic bacteria levels observed in the Snake River above the HCC (Harrison 2005).

The other dominant factor is the level of organic matter in hyporheic zone water, which is influenced by organic-matter levels in the water column. The decay of DOC and POC consumes DO in the gravels (Findlay et al. 1993). While plugging can reduce water-exchange rates and the flux of DO and organic matter entering the gravels, lower velocities within the gravels increase the residence time, allowing more time for organic-matter processing and related DO depletion (Kaplan and Newbold 2000).

Low intergravel DO levels above the HCC can be related to the rapid recycling of the more labile dissolved organic matter (Romani et al. 2004) produced in this eutrophic reach of the Snake River (IDEQ and ODEQ 2004; Harrison 2005). Downwelling water-column water with elevated levels of dissolved organic matter will deplete intergravel DO through increased bacterial activity (Kaplan and Newbold 2000). The depletion of DO was also evidenced by the occurrence of anoxic or anaerobic conditions in the gravel (Figure 6.2-8).

Additionally, relatively high nutrient levels support algal, periphyton, and macrophytic production of extracellular dissolved organic matter that stimulates the respiration of polysaccharide-producing bacteria in the sediments (Bell and Sakshaug 1980; Kaplan and Newbold 2000). The secondary production in the sediments can increase organic-matter levels within gravels. And, while most organic matter is produced in the warmer periods, materials produced during the growing season are susceptible to sloughing during the colder winter periods (Park and Clough 2004), then settle and are resuspended as river velocities fluctuate.

Dissolved organic matter that infiltrates a redd can greatly affect DO dynamics in the redd (Soulsby et al. 2001a,b). Also, when vertical movement of water through the redd is slowed due to plugging, the hydrodynamics change, allowing for more ambient hyporheic water to influence the redd (Soulsby et al. 2001a). This process is detrimental in reaches where ambient hyporheic water is anoxic or very low in DO (e.g., upstream of the HCC). POC produced or buried in sediments (including biofilms) can cause anaerobic layers that contribute oxygen-demanding material to nearby sediments (Kaplan and Newbold 2000). Data showed generally increasing levels of POC in the water column above the HCC (Figure 6.2-7) that can mix with gravels under higher water conditions. The decay of organic matter in the gravels was indicated by anoxic conditions prevalent upstream of the HCC (Figures 6.2-8, 6.2-9, and 6.2-10).

Data collected above and below the HCC demonstrated organic matter assimilation was higher in a reservoir reach compared to a river reach. The data showed the HCC improved intergravel DO downstream of the HCC even though water-column levels were depressed. This was caused by the higher level of settling in the HCC reservoirs than in a river. Lower suspended solids and POC levels downstream of reservoirs (Figure 6.2-7) reduced inorganic and organic plugging and organic matter decay in gravels. Data collected above and below the HCC demonstrated this difference and the positive effects on intergravel DO.

6.2.2.1.4 Reservoir DO

The aquatic-life criterion established in the SR–HC TMDL as the DO target for the HCC and applied throughout the HCC is Oregon's criterion of no less than 6.5 mg/L (IDEQ and ODEQ 2004). The minimum DO target of 6.5 mg/L applies unless adequate data are available, in which case multiple targets could apply (Table 6.2-1). Currently, DO levels in the HCC do not always meet the 6.5 mg/L criterion. DO in Brownlee Reservoir can become severely degraded, especially during July (Figure 6.2-11), and has occasionally caused fish mortality (Myers et al. 2003). In particular, low DO conditions in the transition zone of Brownlee Reservoir have potentially limited the survival of the white sturgeon (*Acipenser transmontanus*) population in the river from Brownlee Dam upstream to Swan Falls Dam (Jager et al. 2003).

Like temperature, DO is related to hydrologic conditions. Low DO is typically more widespread and longer in duration during low water years. During low water conditions, anoxia can develop as early as April near the bottom of the reservoir in the transition zone. Anoxia typically continues to build through the season, gradually depleting oxygen from the transition zone, metalimnion, and hypolimnion. The metalimnion, hypolimnion, and a significant volume of the transition zone are typically anoxic by the end of July (Figure 6.2-11). As inflows begin to cool in September, anoxic waters are gradually mixed out of the transition zone and upper levels of the metalimnion into the epilimnion near the dam. The lowest DO levels in the epilimnion near the dam and in Brownlee outflow are typically seen through September.

In higher water years, anoxic conditions first develop downstream of the transition zone and in the hypolimnion (Figure 6.2-11). This is due to a combination of warmer hypolimnion water (and faster oxygen depletion rates) in high water years resulting from a larger Brownlee spring drawdown for flood control and high inflow. While anoxic conditions are not as widespread as in low water years, the conditions in the hypolimnion can be more extreme with increased production and the accumulation of anoxic products, such as sulfide and ammonia.

Brownlee Reservoir receives waters from the inflowing Snake River that were identified in the SR–HC TMDL as having excess TP concentrations and routinely observed nuisance algal growths (IDEQ and ODEQ 2004). The IDEQ and ODEQ linked these conditions to low DO in the Snake River and Brownlee Reservoir. This is best illustrated in the frequency with which the DO criterion is exceeded in the riverine and transition zones of Brownlee Reservoir. Therefore, the current degraded DO current conditions are a result of the degraded upstream Snake River, and how the excessive nutrients and organic matter flowing into Brownlee Reservoir are processed within the reservoir.

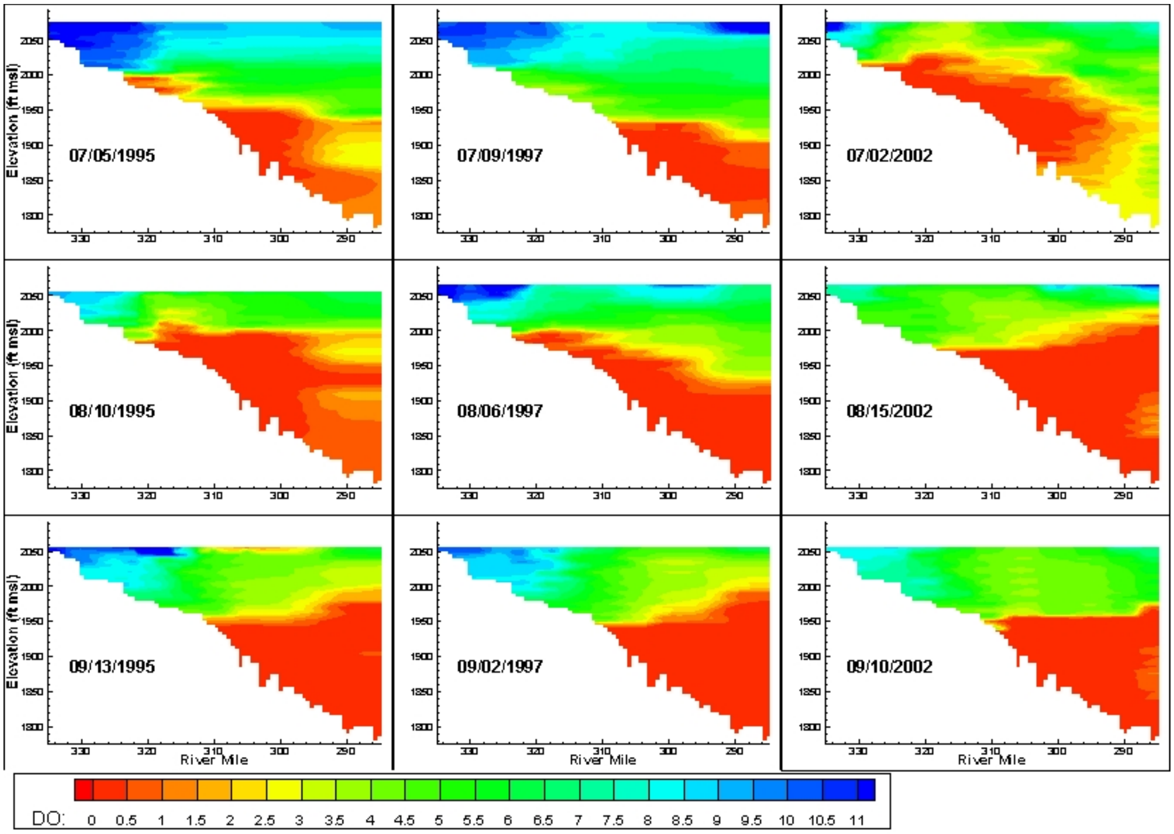


Figure 6.2-11
Measured Brownlee Reservoir DO in mg/L in July, August, and September in an average (1995), high (1997), and low (2002) water year

6.2.2.1.5. Outflow DO

As current conditions in Brownlee Reservoir suggest, outflow DO from Brownlee is typically below applicable criteria beginning in July and going into December (Figure 6.2-12). Overall, the outflow DO from Brownlee Reservoir determines DO levels in Oxbow and Hells Canyon reservoirs and the outflow from HCD. However, DO levels can vary considerably throughout the day in the Brownlee outflow (e.g., 2 to 4 mg/L). In contrast to the daily inflow DO pattern, daily changes in Brownlee outflow DO are related primarily to operations of the Brownlee Powerhouse. A lower flow rate through the powerhouse typically releases slightly deeper water with lower DO levels, while higher flow rates include more surface waters with higher DO levels (Figure 6.2-13). This is because Brownlee Reservoir is thermally stratified with variable oxygen levels through the water column, and changing powerhouse flow rates change the withdraw zone from the reservoir. In addition, there are 5 turbines at Brownlee Powerhouse. Turbines 1 to 4 and turbine 5 initially discharge into separate channels, and the channels combine about 1,200 feet downstream. Due to configurations of the intakes and capacity of the unit, turbine 5 (right channel), tends to draw more surface water with typically higher DO levels from the reservoir, while turbines 1 through 4 (left channel) typically draw waters with lower DO levels. Figure 6.2-13 also shows this relationship with higher DO in the right channel (due to turbine 5 operating at those times).

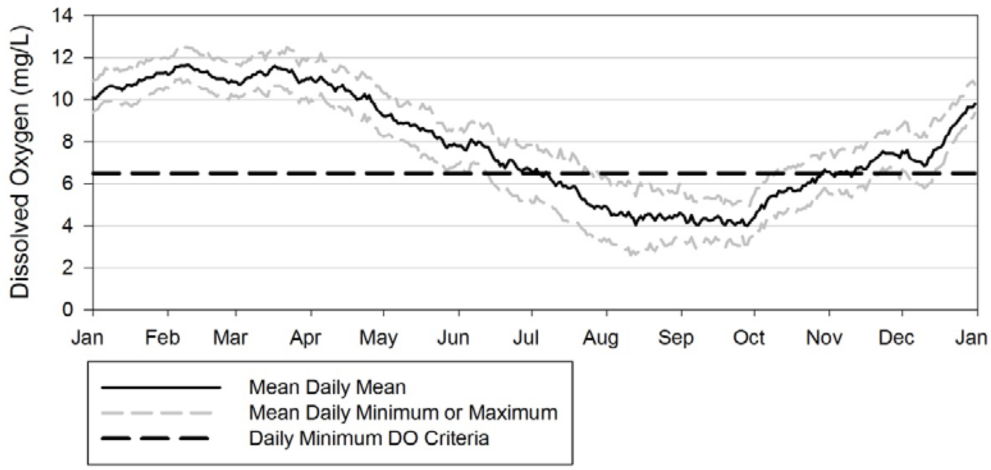


Figure 6.2-12
Brownlee Reservoir outflow mean daily mean, mean daily minimum, and mean daily maximum DO in mg/L summarized from measurements made approximately every 10 minutes over the 2002 through 2012 period. Also shown is the DO criterion of 6.5 mg/L that is applicable to Oxbow and Hells Canyon reservoirs which are immediately downstream of Brownlee Dam.

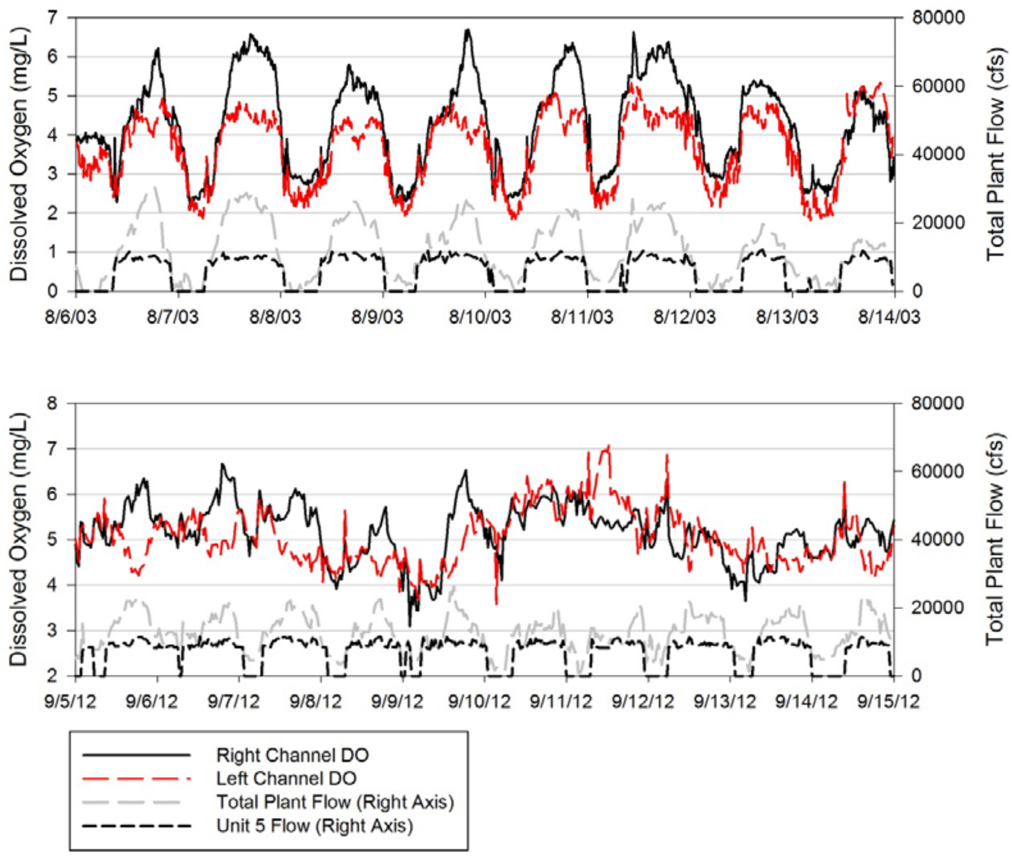


Figure 6.2-13
Brownlee Reservoir outflow DO in mg/L measured every 10 minutes in August 2003 and September 2012 showing the relationship to total plant outflow in cfs. Turbine 5 discharges to the right channel, while turbines 1 through 4 discharge to the left channel (right and left channel locations are when facing downstream).

As water travels from Brownlee outflow, processes (i.e., reaeration, algal production, demand) within Oxbow and Hells Canyon reservoirs may cause increases or decreases in DO levels. Oxbow Reservoir outflowing DO has not been monitored as routinely as Brownlee or Hells Canyon outflows so summaries of the entire 2002 through 2012 period are not possible, however, recent measured data from 2012 were used to show patterns seen in that year.

Analysis of current DO conditions at the inflow and outflow from Oxbow and Hells Canyon reservoirs show that the mixing process occurring in Oxbow Reservoir combined with other in-reservoir processes appear to be causing a slight increase in Oxbow outflow DO compared to Brownlee outflow DO. In Oxbow Reservoir one of the in-reservoir processes is mixing of water with variable DO and flow rates from Brownlee outflow. Because Brownlee outflow DO varies depending on which units are operating and the flow rate (Figure 6.2-13) the daily minimum DO at Brownlee outflow is often associated with a low flow rate (and conversely daily maximum associated with a high flow rate). The result of mixing through Oxbow Reservoir is less variability and typically higher daily minimums in Oxbow outflow (Figure 6.2-14). By the time the water reaches the Hells Canyon outflow, very little daily fluctuation is seen (Figure 6.2-14). In 2012, the change in DO from Brownlee outflow to Oxbow outflow showed an average increase of 0.4 mg/L in daily average DO levels (Figure 6.2-15). In 2012, the magnitude of changes in DO from inflow to outflow of Hells Canyon Reservoir was larger (Figure 6.2-16). While not as consistent as changes through Oxbow Reservoir, trends were similar, with times when DO increased and other times when it decreased. In 2012, the changes in DO from Hells Canyon Reservoir inflow to outflow averaged 0.2 mg/L decrease in daily average DO levels. The data for 2012 are consistent with the general trends identified in data from 2002 through 2012, which showed that the overall net effect of Oxbow and Hells Canyon reservoirs combined was positive relative to DO (Figure 6.2-17).

Despite the general increase in DO as water passes through Oxbow and Hells Canyon reservoirs, conditions in the outflow from Hells Canyon Dam do not always meet downstream standards. For example, Hells Canyon outflow is typically near 4 mg/L in September, which is 2.5 mg/L below the 6.5 mg/L criteria (Figure 6.2-17). However, reaeration occurs relatively quickly through several large rapids immediately downstream of HCD and, depending on conditions (e.g. flow, temperature, etc.), increases can be 1 to 2 mg/L 10 miles downstream (figures 6.2-18 and 6.2-19).

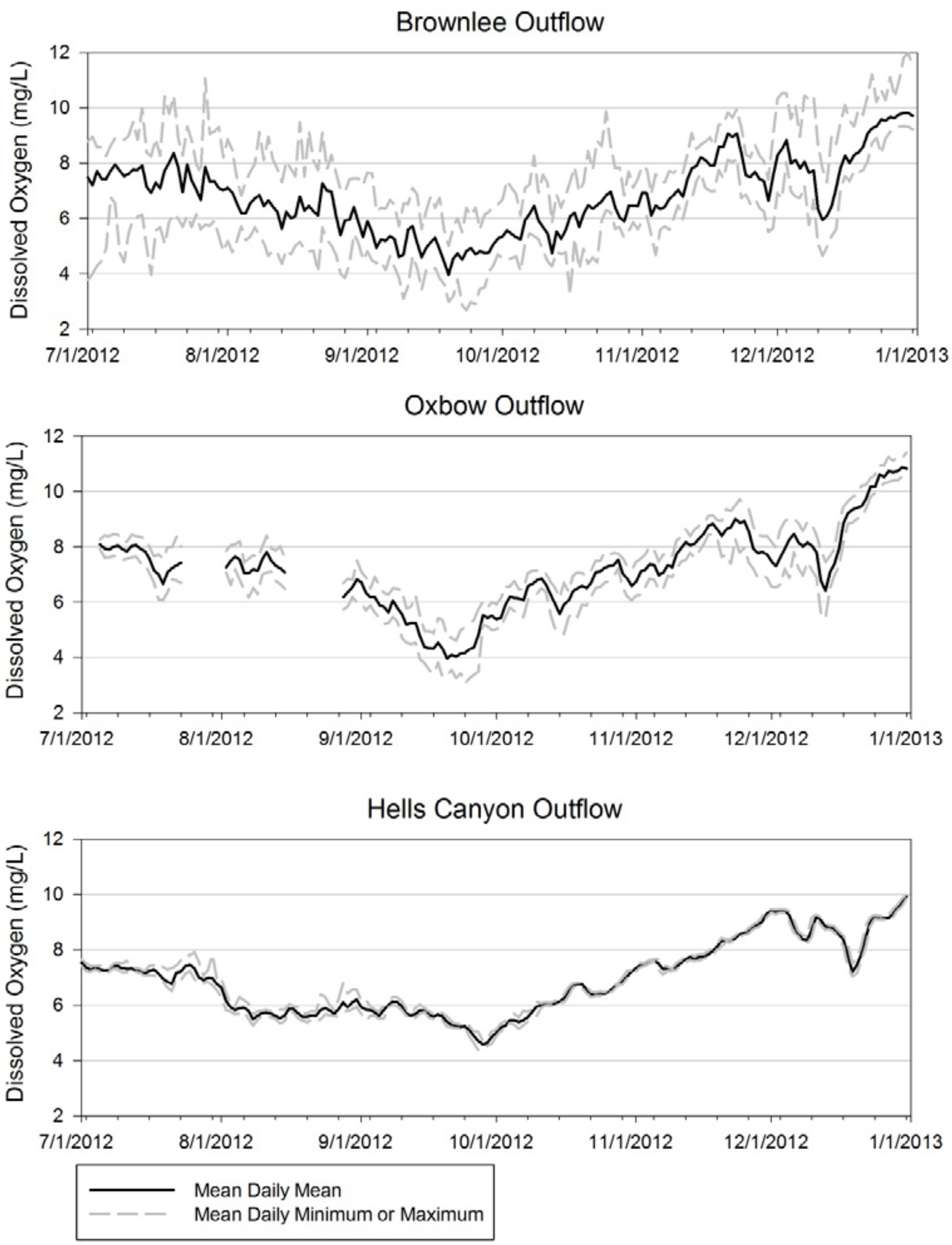


Figure 6.2-14
Daily average, maximum and minimum Brownlee, Oxbow and Hells Canyon Reservoir outflow DO from July through December 2012.

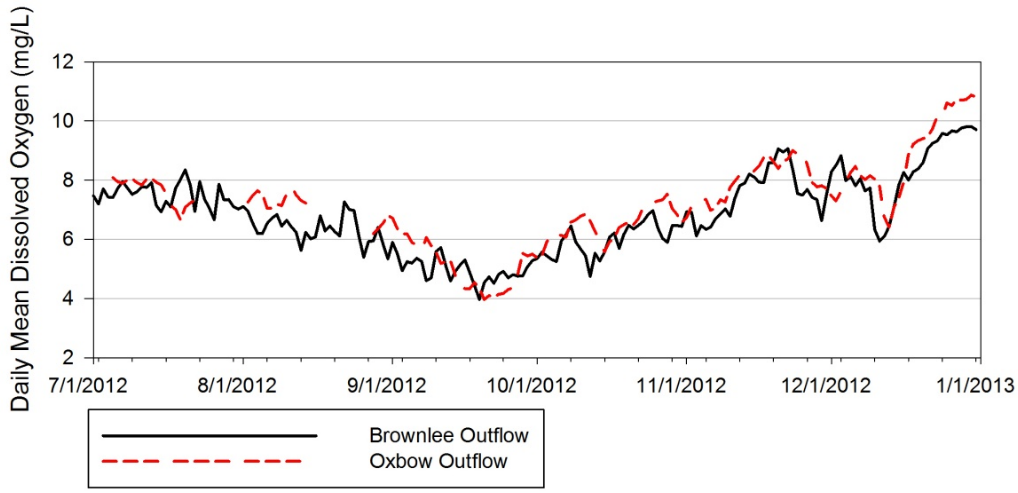


Figure 6.2-15
Daily average, Brownlee and Oxbow Reservoir outflow DO from July through December 2012.

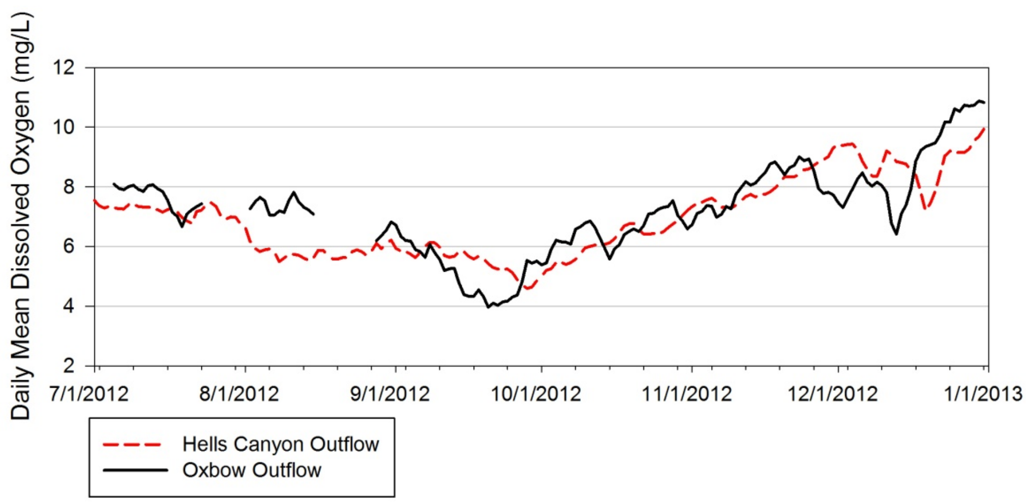


Figure 6.2-16
Daily average, Oxbow and Hells Canyon Reservoir outflow DO from July through December 2012.

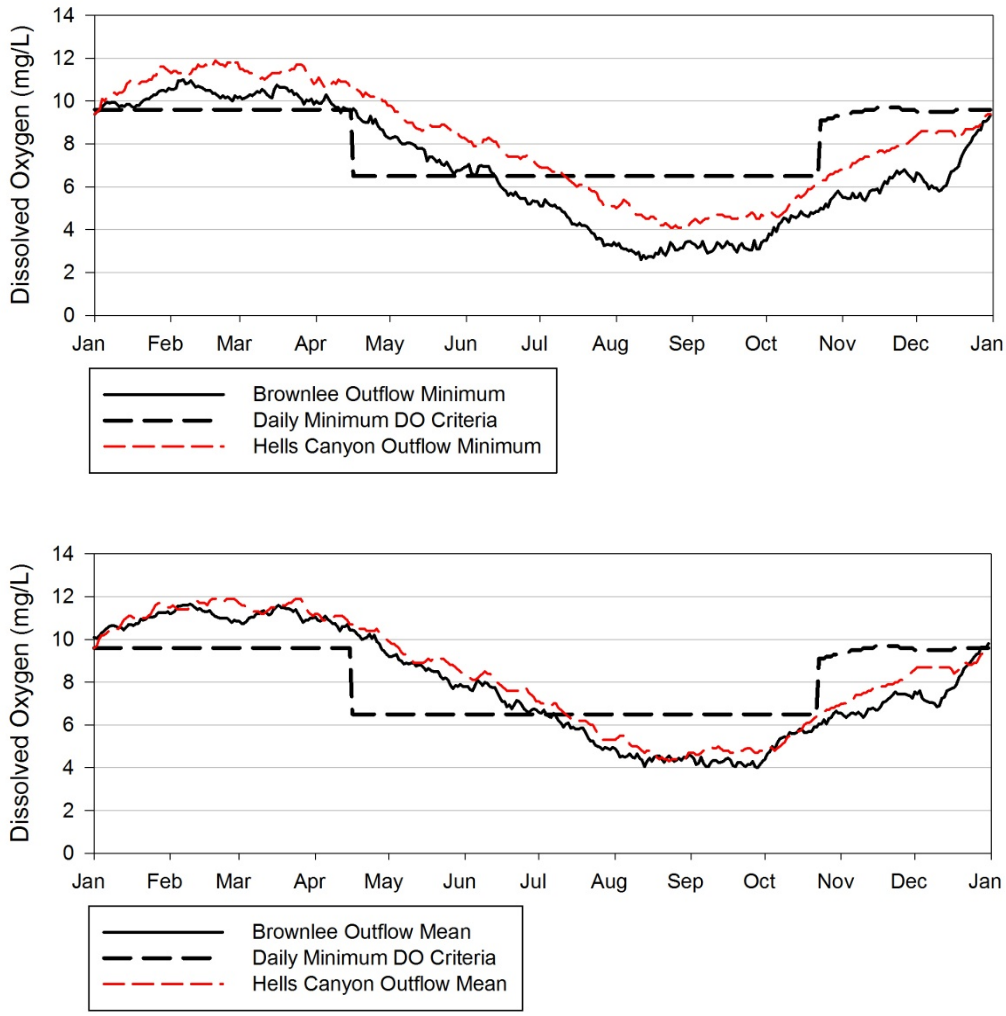


Figure 6.2-17
Hells Canyon and Brownlee Reservoir outflow mean daily minimum (top plot), and mean daily mean (bottom plot) DO in mg/L summarized from measurements made approximately every 10 minutes over the 2002 through 2012 period. Also shown are applicable criteria of 6.5 mg/L and during the salmonid spawning period below HCD.

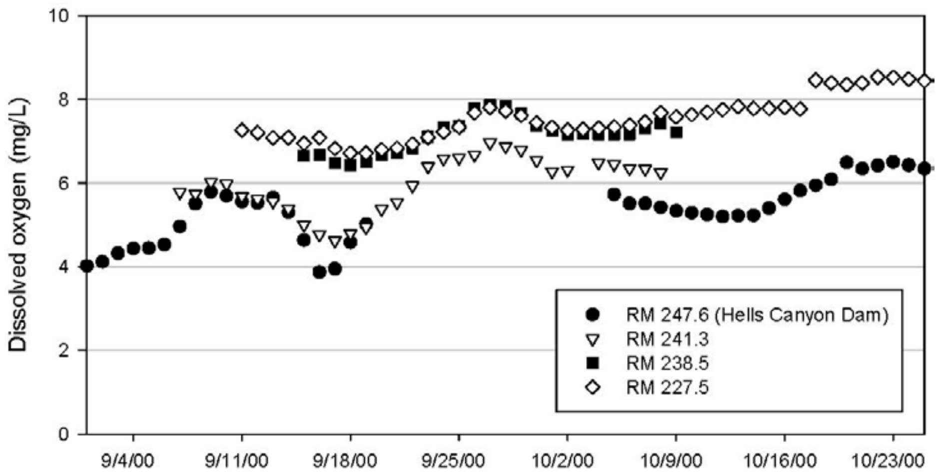


Figure 6.2-18
Daily average DO in mg/L from Hells Canyon Reservoir outflow (HCD) and 3 locations in the Snake River downstream during September and October 2000

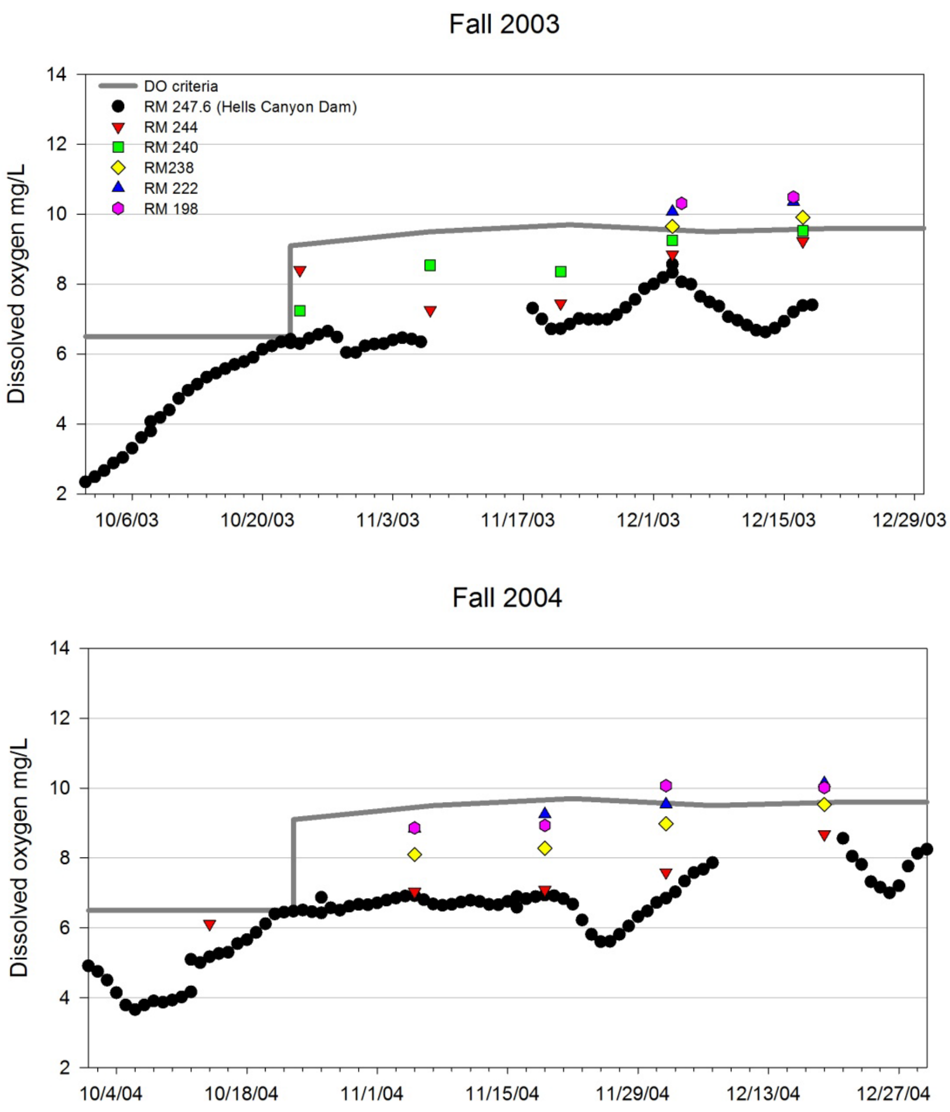


Figure 6.2-19
Water-column DO in mg/L at sites downstream of HCD compared with the daily average (calculated from 10-minute readings) outflow DO measured in the penstock of HCD (RM 247.6) in fall 2003 and 2004

6.2.2.1.6. Oxbow Bypass DO

The Oxbow Bypass is a short, 2.5-mile section of the Snake River below Oxbow Dam. The bypass extends from Oxbow Dam (RM 272.5) downstream to the powerhouse (RM 270). A minimum flow of 100 cfs is maintained through the bypass by drawing water from Oxbow Reservoir approximately 30 feet below full pool and passing it over the Oxbow spillway. The Oxbow Bypass is also subject to inundation by Hells Canyon Reservoir due to the backwater effect of HCD. Indian Creek (RM 271.3) is the only perennial tributary to the bypass.

A deep-water pool exists just upstream of the Indian Creek confluence, approximately 1.2 miles downstream of Oxbow Dam. The pool is approximately 50 feet deep and roughly 2 acres in surface area. The 100-cfs flow rate is not enough to completely mix this deep pool and, at times, the pool thermally stratifies during the summer (Myers and Chandler 2003). The thermal stratification results in the deeper, cooler water becoming anoxic during some parts of the summer season. More detail on the water quality of the Oxbow Bypass is available in Technical Report E.3.2-1 of the *New License Application: Hells Canyon Hydroelectric Complex*. The proposed method to prevent anoxic conditions from developing in the deeper water can be found in Section 7.2.3. Destratification Measure for Oxbow Bypass.

6.2.2.2. Modeling to Assess Expected Future Conditions Relative to Standards

To support the FERC license application process, IPC developed CE-QUAL-W2 models for Brownlee, Oxbow, and Hells Canyon reservoirs (Zimmerman et al. 2002). Models were initially developed for 1992, 1994, 1995, 1997, and 1999. These years were selected based on water-year (i.e., flow) conditions combined with data availability for set-up and calibration. The initial calibration effort was focused on 1992, 1995, and 1997 for low, medium, and high water years, respectively. Years 1994 and 1999 represent medium-low and medium-high water years, respectively, and were developed as verification years (i.e., the model settings developed through the calibration of the other years were applied to these years). In 2002, a large data-collection effort by IPC and others provided additional information relative to inflowing Snake River organic matter, including algae (Harrison 2005). Also studied were Brownlee hydrodynamics, temperature stratification, DO dynamics, meteorological conditions, and intake-channel configuration (Botelho et al. 2003; Botelho and Imberger 2007). A 2002 CE-QUAL-W2 model was developed using this additional information and considerably improved uncertainty associated with the existing low-water-year model (i.e., 1992). After the 2002 model was developed, many of the updates were applied to the other years.

The modeling analysis presented in this section uses 3 of the 6 years—1995, 1997, and 2002. Average water-year conditions are represented by the 1995 model. The inclusion of 1995 is consistent with SR–HC TMDL development, which focuses on conditions during average water years. The inclusion of 2002 allows an evaluation of the low-water conditions, which are typically when the lowest DO conditions are seen in historical data. The relatively extensive boundary condition data available make 2002 a logical selection for low-water-year analysis. The high-water year (1997) is also included in this analysis because while DO levels were generally higher, they were still below applicable criteria.

The general calibration process for the HCC models is described in Harrison et al. (1999) and Zimmerman et al. (2002). The majority of the calibration effort was focused on conditions in Brownlee Reservoir where physical and biological processes are more complex. Also, field studies consistently show that conditions in Oxbow and Hells Canyon reservoirs are driven by Brownlee outflow conditions. Model calibration for all the years was re-evaluated following the development of the 2002 model and applying upgrades and improvements to the other years. We used several methods to analyze model output for comparing model runs and improving its calibration. These methods included animations of various water-quality constituents over time, time-series plots of the outflow constituents, and contour and profile plots at various locations and times in the reservoir. We also used an absolute mean error (AME) analysis as a quantitative means of assessing in-reservoir calibration. Measured DO collected at multiple depths and locations in the reservoir was compared with modeled values and summarized to show the overall error over the year. The equation for the AME can be described as follows:

$$AME = \frac{\sum|X_m - X_d|}{N}$$

Where:

X_m = modeled value
X_d = measured value
N = the number of data pairs

Overall, the 1995, 1997, and 2002 models simulated Brownlee in-reservoir DO with an AME of less than 2 mg/L (Table 6.2-8).

Table 6.2-8
CE-QUAL-W2 DO calibration error statistics for Brownlee Reservoir for the 1995, 1997, and 2002 models

Model Year	AME (mg/L) Brownlee In-Reservoir	Water-Year Type
1995	1.41	Medium
1997	1.65	High
2002	1.10	Low

All reservoir models were initially developed based on actual reservoir operational conditions that occurred in each of the years. For the modeling analysis relative to DO, IPC used operations as defined in the FERC FEIS (FEIS operations). This is significant in interpreting model run results because future operations are not absolutely defined at this time. In addition, operational constraints will necessarily have some level of flexibility allowed within the defined constraints. For example, potential future operational requirements detailed in the FERC FEIS differ somewhat from the requirements in the current license, as well as those proposed by IPC in the license application. The FEIS operations used in this analysis include operating Brownlee within 1 foot of flood-control targets on April 15, drafting Brownlee Reservoir to 2,060 feet by August 1 to provide 237,000 acre-feet of flow augmentation, and continuing the fall Chinook Flow Program.

6.2.2.2.1. Reservoir DO Modeling

Long-term reservoir DO conditions were simulated using the CE-QUAL-W2 model. Dissolved phosphorus and organic phosphorus sources (e.g., labile and refractory organic matter) were reduced in the Brownlee Reservoir inflows to simulate how the reservoir would respond to the SR–HC TMDL TP target of 0.07 mg/L (Myers et al. 2003; IDEQ and ODEQ 2004). This was accomplished by reducing dissolved phosphorus and organic phosphorus (organic matter, including algae) from current conditions or baseline boundary conditions so inflowing TP levels did not exceed 0.07 mg/L. In addition, total organic matter (TOM) loads and sedimentation are expected to decrease as watershed management actions are implemented to meet the TP target. As loads decrease and existing TOM decays through natural processes, sediment oxygen demand (SOD) will decrease. The simulated long-term reservoir conditions included reductions in SOD. SOD is simulated in CE-QUAL-W2 using 2 settings, a zero order (SOD) and first order (SED).

A response to long-term improvements was simulated by reducing the modeled zero-order SOD to 0.1 grams (g) of oxygen per square meter (m^2) per day throughout Brownlee Reservoir. This SOD level is more typical of naturally occurring levels (Cole and Wells 2002). The SED, resulting from the settling of inflowing organic matter, was left at optimized (i.e., current) rates (Harrison et al. 1999). This simulation methodology follows the same method used during the development of the SR–HC TMDL (IDEQ and ODEQ 2004).

CE-QUAL-W2 DO simulation results indicated that when the SR–HC TMDL is fully implemented, DO levels in Brownlee Reservoir are expected to improve dramatically (Figure 6.2-20). These simulation results showed that the greatest improvements in DO conditions are expected to occur in late summer. The simulations included a reduction of algae (and other organic matter components), as anticipated with full implementation of upstream allocations, and an associated decrease in SOD (long-term improvements).

To mitigate the effects of Brownlee Reservoir, as identified in the SR-HC TMDL. IPC will implement Snake River phosphorus-reduction measures to meet the load allocation of 1,125 tons of DO per year in Brownlee Reservoir (IDEQ and ODEQ 2004). The specific methodology and proposals for this implementation can be found in Section 7.2. DO Proposed Measures. For an analysis of long-term conditions, IPC's implementation of the load allocation was not represented in this CE-QUAL-W2 modeling.

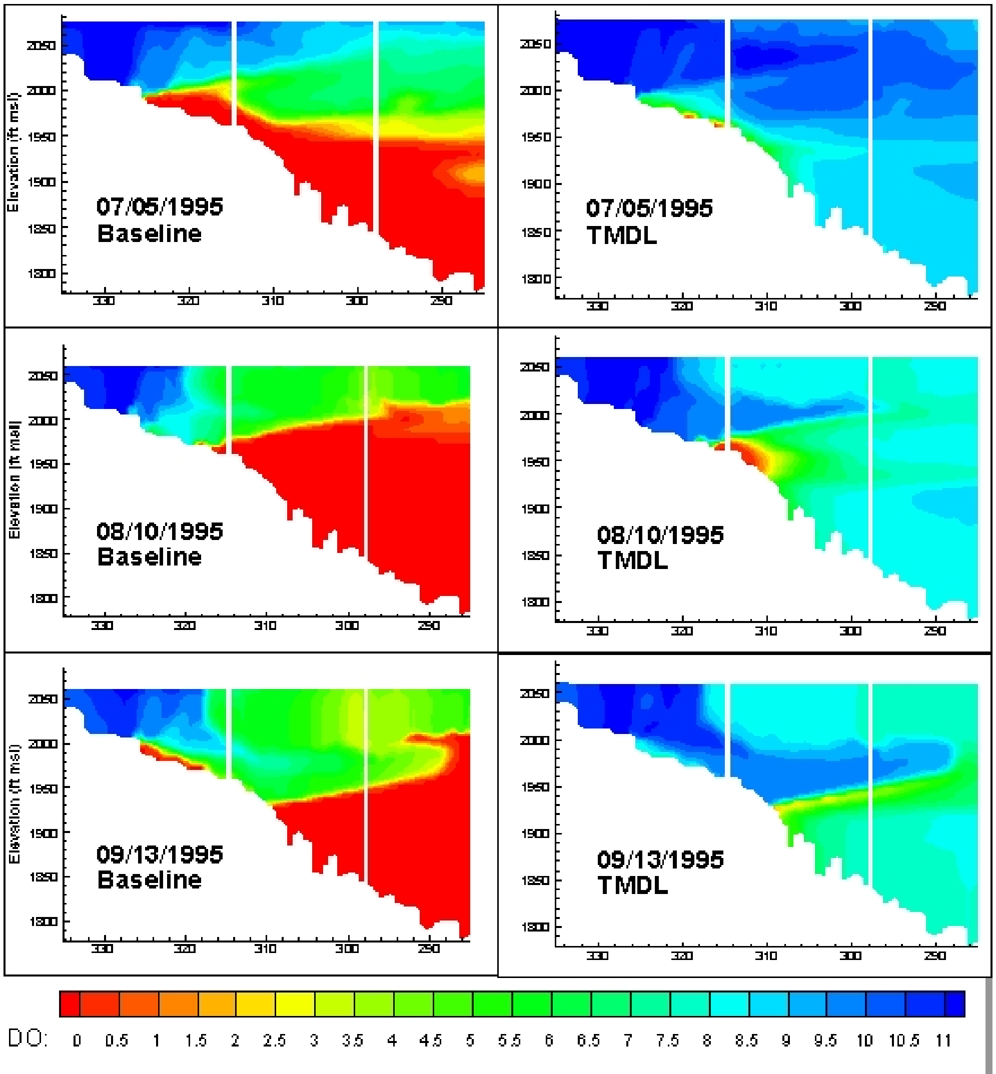


Figure 6.2-20
CE-QUAL-W2 simulated DO in mg/L in Brownlee Reservoir for 1995 current conditions (baseline) and anticipated conditions with full upstream implementation of the SR–HC TMDL (TMDL)

6.2.2.2.2. Outflow DO modeling

The SR–HC TMDL did not address DO downstream of the HCC, and targets were not developed to meet the salmonid spawning criteria. The SR–HC TMDL assigned upstream TP allocations so the Snake River flowing into the HCC met aquatic-life criteria and protected those beneficial uses (IDEQ and ODEQ 2004). The SR–HC TMDL did not develop targets or allocations based on more stringent downstream criteria for the protection of salmonid spawning. It did identify that the HCC's contribution to any DO deficit was related only to the impoundments. The water-quality improvements resulting from the full implementation of the SR–HC TMDL include improved DO below the HCC (Figure 6.2-21). The CE-QUAL-W2 model was used to simulate improvements in Hells Canyon Reservoir outflow DO following full upstream SR–HC TMDL implementation. Improvements are based on the difference between simulated HCC outflow DO with current conditions and with full SR–HC TMDL implementation.

To summarize, simulated DO levels below the HCC resulting from full implementation of the SR–HC TMDL were assessed by modifying the Brownlee Reservoir boundary conditions and the CE-QUAL-W2 model (see Section 6.2.2.2.1. Reservoir DO Modeling).

- Reduce inflowing nutrients and organic matter at the Brownlee Reservoir boundary conditions (RM 340) to meet the SR–HC TMDL TP target of 0.07 mg/L.
- Increase inflow DO at the Brownlee Reservoir boundary conditions to meet the SR–HC TMDL DO target of 6.5 mg/L.
- Set the SOD at long-term levels of 0.1 g of oxygen per m^2 per day throughout Brownlee Reservoir.
- Use outflow from the upstream reservoir as the inflow boundary condition to the downstream reservoir (referred to as linked simulations) and set the SOD to 0.1 g of oxygen per m^2 per day.

The linked simulation modeling outflow from the HCC after full implementation of the SR–HC TMDL showed DO improvements from 2 to 5 mg/L during the summer and 2 to 4 mg/L during fall (Figure 6.2-21). This was compared to summarized, measured DO data collected in water discharged from HCD of approximately 4 to 5 mg/L (Figure 6.2-17). Comparing SR–HC TMDL improvements with summarized measured data shows that full upstream SR–HC TMDL implementation would likely improve HCC outflow DO enough to fully meet the downstream criterion of 6.5 mg/L for the protection of cool water aquatic life but not enough to fully meet the water-column salmonid-spawning criteria.

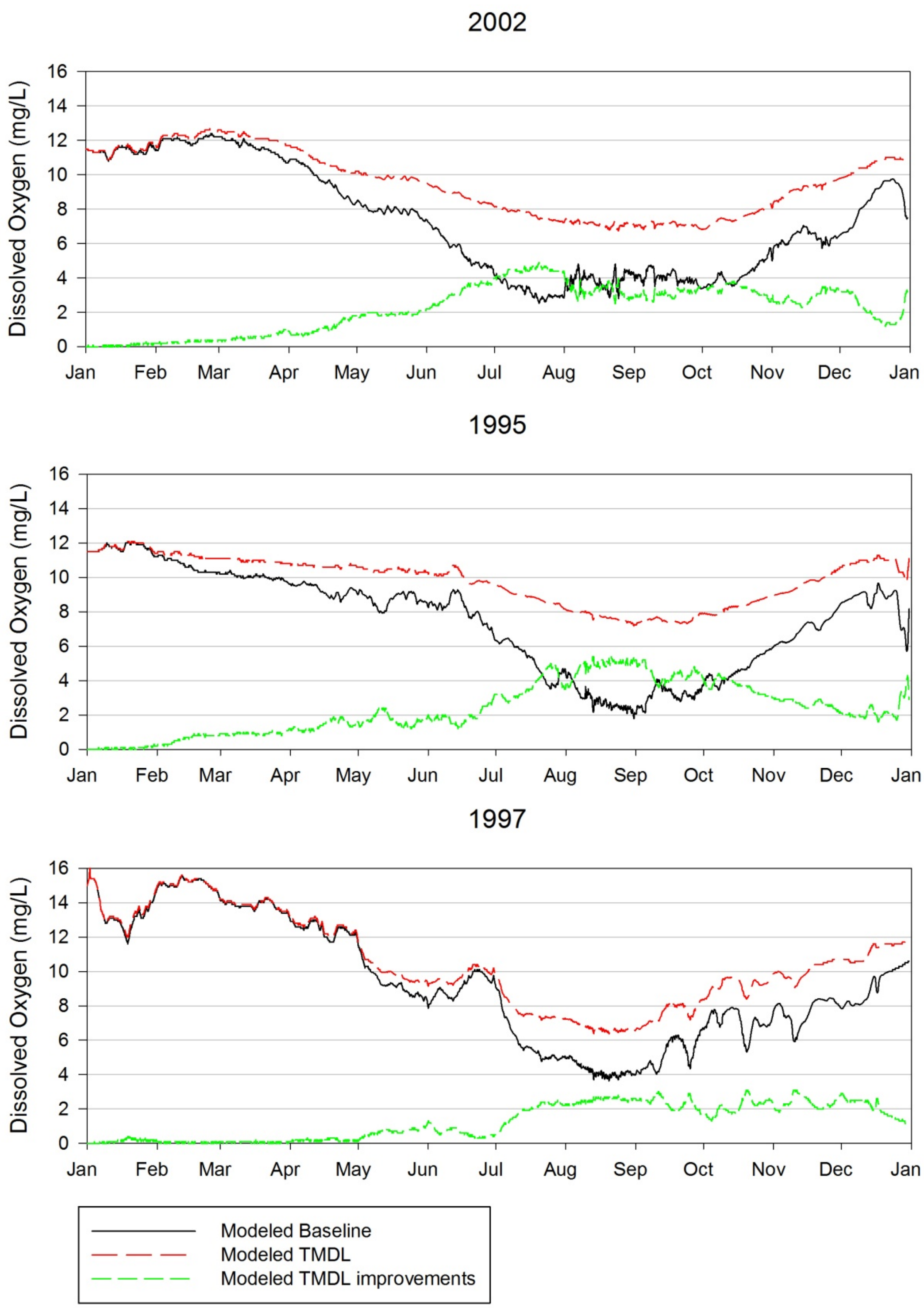


Figure 6.2-21
Comparison of simulated Hells Canyon Reservoir outflow DO in mg/L with current conditions and SR–HC TMDL conditions. TMDL improvements show the difference between the 2 simulations.

6.2.3. HCC Contribution to DO

Brownlee, Oxbow, and Hells Canyon reservoirs are all affecting DO conditions in different ways and magnitude. Further, the effects of each individual reservoir, as well as the HCC as a whole, varies among years and will inevitably vary through the term of the 401 certification. IPC used a combination of information and analyses from the SR-HC TMDL, and additional analyses and data beyond the SR-HC TMDL to assess the level of mitigation necessary to offset the effects of the HCC on DO.

The SR-HC TMDL defined the contribution of Brownlee Reservoir to degraded DO conditions within the reservoir, and assigned a specific DO load allocation to IPC. The SR-HC TMDL provided a comprehensive and robust analysis of the relative contribution and effects of Brownlee Reservoir on DO conditions within the HCC. A DO load allocation of 1,125 tons per year was established for Brownlee Reservoir. The SR-HC TMDL was approved by EPA and still represents the best available information regarding the effects of Brownlee Reservoir on DO.

The SR-HC TMDL did not address the effects of Oxbow and Hells Canyon reservoirs on DO conditions downstream of Brownlee Reservoir. Subsequent to the SR-HC TMDL approval, IPC has conducted additional analyses as part of the 401 application process to characterize the effects of Oxbow and Hells Canyon reservoirs on DO both within the HCC and downstream.

6.2.3.1. Brownlee Reservoir

Idaho Power's DO allocation, as established in the SR-HC TMDL (IDEQ and ODEQ 2004), was calculated by IDEQ and ODEQ using a mass balance approach. The analyses relied on available data and on the determination by the DEQs that IPC would focus on the impoundment effects attributed to the reservoirs. This was stated in the SR-HC TMDL as follows:

> Because there are both total phosphorus and dissolved oxygen load allocations assigned within different segments of the SR-HC TMDL reach, it must be clearly understood that Upstream Snake River segment (RM 409 to 335) pollutant sources are responsible for those water quality problems occurring in the Upstream Snake River segment. They are not responsible for those water quality problems that would occur if the waters flowing into Brownlee Reservoir met water quality standards and are exclusive to the reservoir. Similarly, IPCo (as operator of the Hells Canyon Complex) is responsible for those water quality problems related exclusively to impoundment effects that would occur if inflowing water met water quality standards. (SR-HC TMDL pg 450)

The DEQ used a mass balance analysis to determine the reservoir DO deficit after upstream reductions in nutrients. Using a mass balance approach, they set the allocation for two reservoir zones:

> The dissolved oxygen allocation requires the addition of 1,125 tons of oxygen (1.02 x106 kg) into the metalimnion and transition zone of Brownlee Reservoir (approximately 17.3 tons/day (15,727 kg/day)). The total dissolved oxygen mass required to address the loss of assimilative capacity in the metalimnion over this time frame is 1,053 tons (957,272 kg). This is equivalent to an even distribution of 16.2 tons/day (14,727 kg/day) over 65 days. The total dissolved oxygen mass required to address the loss of assimilative capacity in the

> transition zone over this time frame is 72 tons (65,454 kg). This is equivalent to an even distribution of 3.0 tons/day (2,727 kg/day) over 24 days. (SR-HC TMDL pg 450)

To support this allocation, IPC provided reservoir modeling (SR-HC TMDL Appendix 7) that had been developed with support from Tom Cole/USBR and Scott Wells/PSU, the model developers. Prior to performing the SR-HC TMDL modeling, the model was peer reviewed by agency modelers including: John Yearsley/EPA, Stuart Woods/USGS, and Merlin Bender/USBR. Additionally, prior to using IPC modeling to support the SR-HC TMDL allocations, the DEQs, with EPA, performed their own publicly attended modeling review effort that included additional review by stakeholders, agencies, NGOs and others.

Based on this extensive model review effort, the DEQ's concluded:

> Although it was recognized in all peer reviews that no model will ever be a perfect fit for any system, all reviewers from all of the peer review efforts indicated that they felt confident with the manner in which the model had been validated and applied to the Hells Canyon Complex (SR-HC TMDL pg 300).

The DEQ review process included assessment of the CE-QUAL-W2 model formulation, boundary and initial condition settings, parameterization, and calibration. And while the model continues to evolve, it should be noted that the organic matter and sediment modeling approaches used to model Brownlee to support the SR-HC TMDL are consistent with the most current public release version of CE-QUAL-W2. The sediment modeling approach used both a zero order model (SOD) and a first order model (SED) to represent current and future organic matter degradation. Other more research oriented sediment diagenesis models were and are available, but still lack the rigorous testing needed for broad application. Therefore, the analyses and determination relative to the effects of Brownlee Reservoir that is contained within the EPA-approved SR-HC TMDL remains viable, and in fact, represents the best available information regarding the contribution of Brownlee Reservoir to degraded DO conditions within the reservoir.

6.2.3.2. Oxbow and Hells Canyon Reservoirs

Because Oxbow and Hells Canyon reservoirs were not explicitly assigned a level of responsibility for DO conditions within the HCC, IPC is not able to rely on the SR-HC TMDL to define the level of DO effects associated with those specific projects. Therefore, IPC used DO data that has been collected over the past 20 years to characterize the effects of Oxbow and Hells Canyon reservoirs on DO. Based on the long term data set, Oxbow and Hells Canyon reservoirs appear to have a slight overall positive effect on DO when inflowing levels of DO are compared to outflowing DO levels. Data from 2012 increases the resolution and shows that there may be periods of time through the low DO season when Hells Canyon Reservoir is having a slight negative effect on outflow DO while during other periods in the season a positive effect is seen. IPCs proposal in Section 7.2 DO Proposed Measures will address any negative effects to HCD outflow DO that may be occurring through the lower two reservoirs.

6.2.3.3. Downstream

Currently Hells Canyon outflow DO is below applicable criteria beginning in July through the end of the December (Figure 6.2-17). As discussed previously, these deficits are primarily a result of degraded conditions in Brownlee Reservoir that are resulting from excessive levels of inflow nutrient and organic matter and processes occurring within Brownlee Reservoir. The SR-HC TMDL quantified the contribution of Brownlee Reservoir to the degraded DO conditions upstream of Oxbow. Further, in Section 6.2.2.1.5. IPC presented data and analysis that quantified the effects of Oxbow and Hells Canyon reservoirs using measured data.

Modeling indicated that following SR-HC TMDL implementation there remains a potential deficit at the HCD outflow relative to the salmonid spawning criteria (Figure 6.2-22). DO deficit estimates presented below show the estimated DO increase needed to meet the salmonid spawning criteria below the HCC following upstream implementation of the SR–HC TMDL. This estimated DO deficit was derived from a series of modeling and analyses:

1. The modeled SR–HC TMDL improvements in daily minimum DO (Figure 6.2-21) from the 3 model years were averaged to estimate the anticipated improvement over a range of water-year types.

2. The average SR–HC TMDL improvement was added to the measured daily minimum HCC outflow DO to adjust each year of measured data from 1991 to 2012.

3. The adjusted measured data was summarized to show the adjusted mean daily minimum and 95% confidence intervals with anticipated SR–HC TMDL improvements. The adjustment represents accounting for changes in outflow DO anticipated by upstream SR–HC TMDL improvements.

4. The adjusted measured data was compared with criteria to determine a DO concentration deficit. Adjusted measured data showed that, following SR–HC TMDL improvements, outflow DO may still fall below criteria by an average of 0.4 mg/L for the first 29 days of the salmonid spawning period (Figure 6.2-22).

These steps were necessary because model results are best used to assess relative changes between simulations or the relative effectiveness of management options. Comparing model results directly to criteria can be appropriate and conservative, depending on model error estimates, the desired level of resolution, and case-specific considerations. In this situation, comparing model results directly to criteria to estimate deficits and DO loads needed was problematic. Although error estimates of the HCC model applications reported in Table 6.2-8 are not uncommon in similar model applications, an error of 1 to 2 mg/L would result in a substantial over or underestimation of deficits and loads. For these reasons, SR–HC TMDL improvements were used to adjust measured DO data to account for non-HCC DO effects, then compare the DO data with criteria. SR–HC TMDL improvements are the relative DO improvements between 2 model simulations.

IPC proposes to implement distributed aeration at the Brownlee Powerhouse (see Section 7.2. DO Proposed Measures) that will provide, at a minimum, 0.4 mg/L of additional oxygen below HCD during the beginning of the salmonid spawning period and cover any negative effects of

Oxbow and Hells Canyon reservoirs on DO. That level of aeration will cover both the current negative effects of Oxbow and Hells Canyon reservoirs, as well as ensure that downstream standards will be met under full SR-HC TMDL implementation.

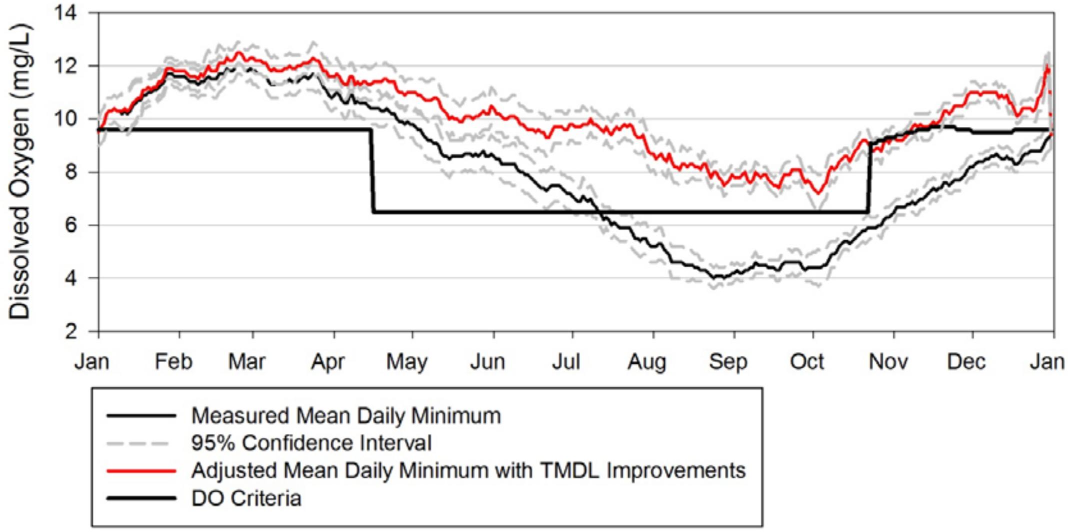


Figure 6.2-22
Hells Canyon outflow measured mean daily minimum DO in mg/L from 1991 to 2012 and adjusted measured mean daily minimum DO based on SR–HC TMDL improvements

6.2.3.3. Oxbow Bypass

The deep pool in the Oxbow Bypass was not specifically included in DO simulations following full SR–HC TMDL implementation. Currently, this deep pool becomes thermally stratified and anoxic conditions occasionally develop in the deep, cooler water during the summer season. Improved DO conditions in Oxbow and Hells Canyon reservoirs following SR–HC TMDL implementation suggest anoxic conditions may no longer develop in this pool. However, this is not known to be the case. Therefore, IPC will address the development of anoxic conditions in the deep pool in the Oxbow Bypass. Specific measures to accomplish this are described in Section 7.2. DO Proposed Measures.

6.3. TDG

TDG is a measure of the sum of partial pressures of all dissolved gases in water, including water vapor. Typically, in most natural waters, TDG is a measure of how much nitrogen, oxygen, argon, carbon dioxide, and water vapor are dissolved in a given amount of water. Although slightly elevated TDG levels can occur naturally, a TDG saturation of 100% means the water is saturated relative to atmospheric conditions. Levels exceeding 100% of saturation, or supersaturation, can be detrimental, or even lethal, to aquatic life.

Gas supersaturation downstream of large-scale hydroelectric projects typically occurs when air becomes entrained in water released over a spillway and plunges deep into a stilling basin. The hydrostatic pressure at depth causes entrained atmospheric gases to be absorbed into solution. This process creates the supersaturation of gases relative to surface or atmospheric pressures. Also, oxygen production by aquatic plants through photosynthesis can cause supersaturated conditions (Goldman and Horne 1983).

The solubility of atmospheric gases in water is primarily affected by temperature and pressure. While increased temperature decreases the solubility of gases in water, increased pressure on a liquid enhances its capacity to hold dissolved gases. Pressure at depth, caused by greater hydrostatic head, allows deeper water to hold more dissolved gases than shallow water. Each meter of depth increases the solubility of the dissolved gases to compensate for approximately 10% of the supersaturation (Weitkamp and Katz 1980). Consequently, the depth distribution of the organisms determines the effects of TDG levels on aquatic life. For example, a surface measurement of 120% of saturation corresponds to a compensated effect to aquatic life of 110% of saturation 1 m below the surface. In reservoirs and large rivers with elevated TDG levels, such as the HCC and Snake River downstream, little of the water volume is likely to have supersaturation gas effects on aquatic organisms (Weitkamp 1974).

The Oregon *2012 Integrated Report* (ODEQ 2014) does not have the Snake River or the HCC reservoirs listed as impaired by TDG (Table 5.1-1). Idaho's *2012 Integrated Report* (IDEQ 2014) listed TDG in category 4a as a pollutant impairing beneficial uses with a TMDL completed and approved in Oxbow and Hells Canyon reservoirs and the Snake River downstream of HCD to the confluence with the Salmon River (Table 5.1-2). A loading analysis performed by the IDEQ and ODEQ for the SR–HC TMDL identified that elevated TDG levels in the Snake River from Brownlee Dam to the confluence with the Salmon River were the result of releasing water over spillways of dams in the HCC, stating spills at Brownlee Dam and HCD were the sources of elevated TDG (IDEQ and ODEQ 2004). As such, the entire load was allocated to IPC. The load allocation is less than 110% of saturation at the edge of the aerated zone and applies to each location where spill occurs except when flow exceeds the 10-year, 7-day (7Q10) average flood.

6.3.1. TDG Standards and SR–HC TMDL Targets

Oregon and Idaho both have numeric criterion not to exceed 110% of saturation at atmospheric pressure at the point of sample collection (OAR 340-041-0031(2))[29] and IDAPA 58.01.02.250.01.b.). This criterion does not apply with respect to excess flows. In Oregon, the criterion does not apply when flows exceed the 7Q10 average flood. In Idaho, the director of the IDEQ has the authority to specify the applicability of the gas supersaturation criterion with respect to excess flow (IDAPA 58.01.02.300.01.a.).[30] The SR–HC TMDL identified excess flow as the Oregon standard and the point of sample collection as the edge of the aerated zone (IDEQ and ODEQ 2004).

[29] Oregon also has a 105%-of-saturation criterion specific to hatchery-receiving waters and waters less than 2 feet deep that does not apply to the HCC.

[30] With respect to gas supersaturation, the IDEQ director also has the authority to 1) direct all known and reasonable measures to be taken to ensure the protection of fishery resources and 2) require operational procedures or project modifications not to contribute to increased mortalities of juvenile migrants or impose serious delays in adult migrant fishes (IDAPA 58.01.02.300).

6.3.2. Conditions Relative to TDG

Spilling at the HCC projects is almost exclusively involuntary, occurring usually as a result of flood-control constraints or high-runoff events (IDEQ and ODEQ 2004). Spilling typically occurs between December and July in higher water years when Snake River flows exceed the project's flood-storage capacity, as mandated by the USACE, or the hydraulic capacity of generation turbines. Other unusual situations, including emergencies or unexpected unit outages, can induce a spill episode at any of the projects.

Spilling water at any of the 3 projects within the HCC can increase TDG to supersaturation levels that exceed the 110% of saturation criterion. TDG levels were measured immediately downstream of the spillway and do not necessarily represent levels at the edge of the aerated zone. During spills above 3,000 cfs at Brownlee Dam, TDG levels in spilled water consistently exceeded the 110% of saturation criterion and were measured as high as 128% (Figure 6.3-1). TDG levels downstream of the spillway were significantly higher than reservoir levels ($P < 0.005$). The configuration of the Brownlee Powerhouse and spillway creates separation of spill and turbine flows. Monitoring at the bridge immediately below Brownlee Dam indicates limited mixing of spill and powerhouse flows at that location until spill flows reached 35,000 cfs (Exhibit 6.3-1). Assuming full hydraulic capacity of the turbines (approximately 35,000 cfs), this flow (i.e., approximately 70,000 cfs) was higher than the 7Q10 average flood flow of 67,898 cfs. Exhibit 6.3-1 also indicated TDG levels measured below Brownlee Dam can be higher than the maximum of 128% measured in 1997 and 1998, with little dissipation downstream through Oxbow Reservoir.

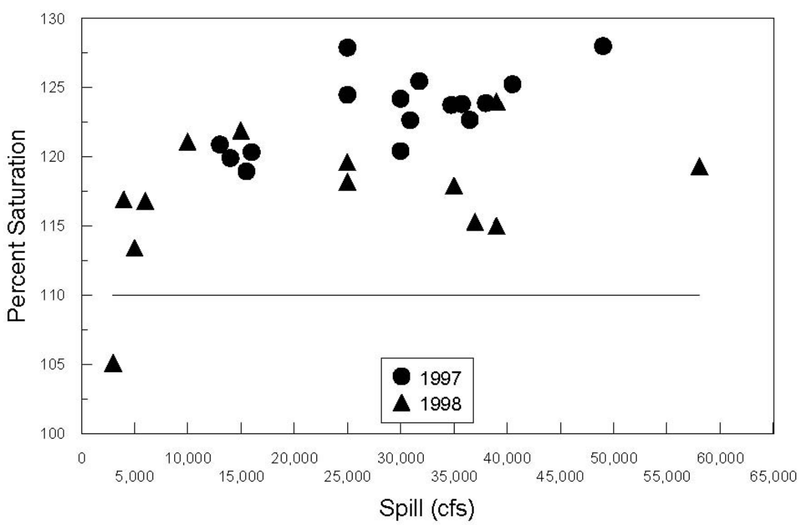


Figure 6.3-1
The relationship of spill in cfs and TDG percent of saturation measured downstream of Brownlee Dam, 1997–1998. (Note: Add 35,000 cfs to spill to estimate the total Snake River flow. The TDG percent of saturation is measured near the spillway prior to mixing with turbine flow.)

TDG levels measured in the spill of Oxbow Dam were similar to those measured in the spill of Brownlee Dam and exceeded the criterion (Figure 6.3-2). In 1997 and 1998, the TDG levels measured at Oxbow Dam did not necessarily represent independent Oxbow Dam spill events, as water was also being spilled at Brownlee Dam. TDG levels in Oxbow Reservoir ranged upwards to 125% of saturation. Evaluation of these data and data collected downstream of Oxbow Dam indicated increases and decreases in TDG levels were measured (Figure 6.3-3). The largest increase in saturation (approximately 20%) occurred during a spill rate of 12,000 cfs. The largest decrease in saturation (approximately 13%) occurred during a spill rate of 2,000 cfs. At Oxbow Dam, spill rates less than 2,000 cfs and greater than 24,000 cfs lowered TDG levels in the spilled water, while spill rates between 5,000 and 24,000 cfs increased TDG levels. Seattle Marine Laboratories (1972) found that dissolved nitrogen (DN) levels decreased on all days sampled as a result of spill at Oxbow Dam, but they did not address rates of spill.

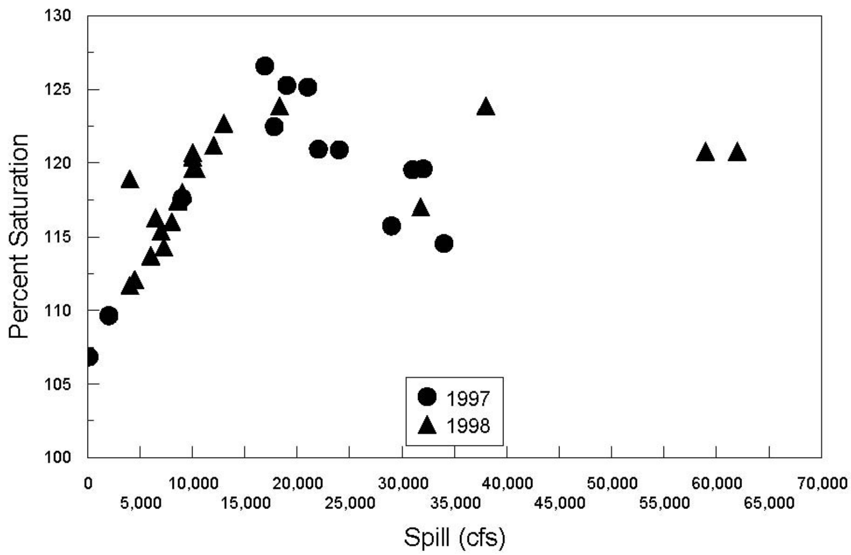


Figure 6.3-2
The relationship of spill in cfs and TDG percent of saturation measured downstream of Oxbow Dam, 1997–1998. (Note: Add 28,000 cfs to spill to estimate the total Snake River flow. The TDG percent of saturation is measured near the spillway prior to mixing with turbine flow.)

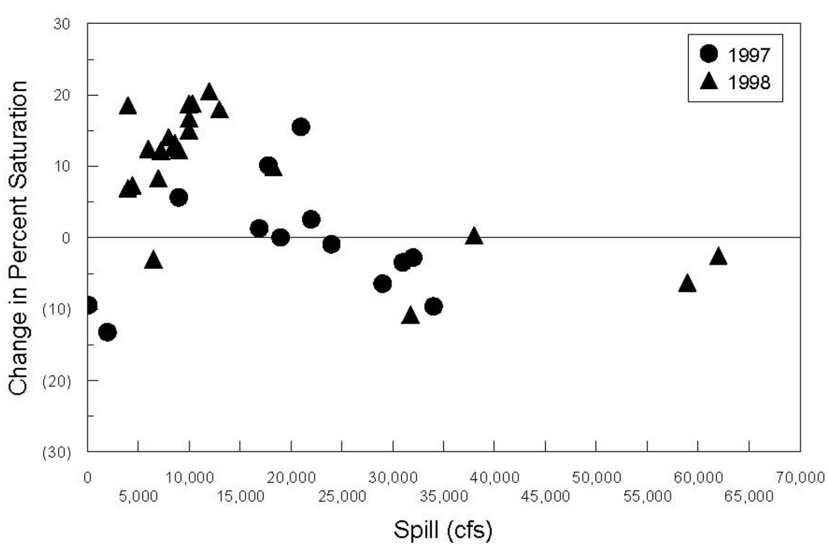


Figure 6.3-3
Change in TDG percent of saturation above and below Oxbow Dam over a range of spill in cfs, 1997–1998. (Note: Parenthetic numbers indicate a decrease in TDG levels below Oxbow Dam.)

Monitoring in 2006 allowed an evaluation of spill at Oxbow Dam independent of Brownlee Dam spill (i.e., when Oxbow Reservoir forebay TDG levels were less than 110% of saturation). These data showed that when the Oxbow Reservoir forebay was below the criterion, spill at Oxbow Dam increased TDG levels to approximately 128% of saturation in the bypassed reach (Figure 6.3-4). As in 1997 and 1998, similar patterns of increases and decreases in TDG levels resulting from spill at Oxbow Dam were also measured (Exhibit 6.3-1).

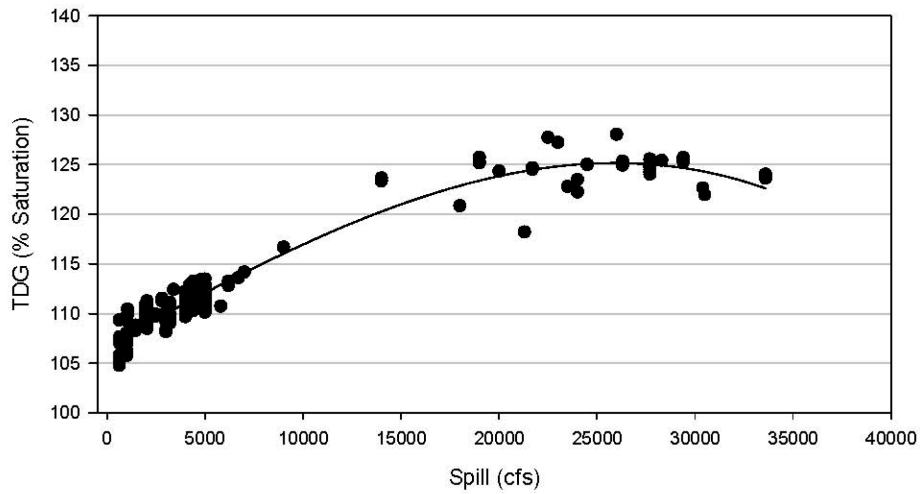


Figure 6.3-4
The relationship of spill in cfs and TDG percent of saturation (% saturation) at Oxbow Dam in 2006 when inflow water to the Oxbow spillway was less than 110% of saturation

TDG levels in the HCD tailwater were significantly higher than reservoir levels during periods of spill ($P < 0.005$), ranging up to 133% of saturation (Figure 6.3-5). Hourly measures taken in 1999 ranged up to 136% of saturation, showing a clear relationship between spill and TDG levels despite considerable variability in TDG at similar spill rates (Figure 6.3-6). Nearly all rates of spill produced TDG levels exceeding the criterion. Supersaturation declined in the Snake River as water flowed downstream of HCD (Figure 6.3-7). Levels in excess of 110% of saturation persisted downstream to the confluence with the Salmon River (RM 188) when spilling approximately 20,000 cfs or greater at HCD. More detail on HCC TDG is available in Technical Report E.2.2-4 (Myers and Parkinson 2003), which accompanied the *New License Application: Hells Canyon Hydroelectric Complex*.

The daily average flow from HCD from 1968 through 2003 was used to generate a flow-duration curve (Figure 6.3-8). The 7Q10 average flood, as calculated below HCD, is 71,498 cfs. This represents less than 1% of the flows at HCD. Similar average flood statistics were estimated for both Oxbow and Brownlee dams by subtracting major tributary flows. The 7Q10 average flood is 69,062 cfs at Oxbow Dam and 67,898 cfs at Brownlee Dam.

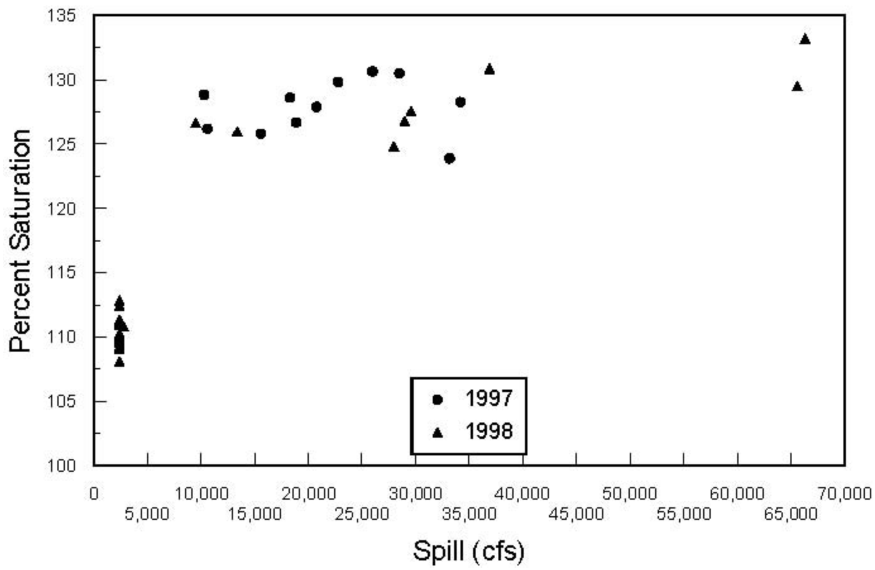


Figure 6.3-5
The relationship of spill in cfs and TDG percent of saturation measured at the Hells Canyon boat launch downstream of HCD, 1997–1998. (Note: Add 30,500 cfs to spill to estimate the total Snake River flow. These data are presumed to represent a mix of turbine and spill waters.)

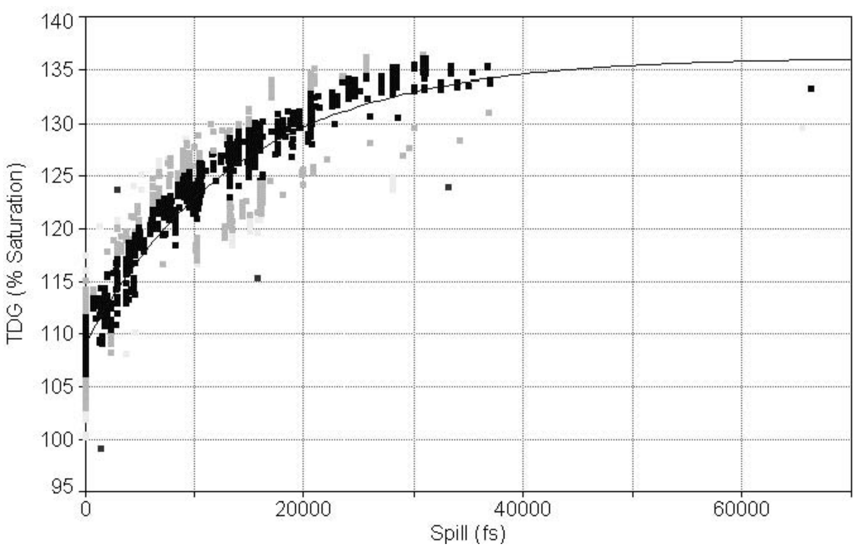


Figure 6.3-6
The relationship of spill in cfs and TDG percent of saturation (% saturation) measured below HCD from March 3–July 20, 1999. (Note: Add 30,500 cfs to spill to estimate the total Snake River flow. These data are presumed to represent a mix of turbine and spill waters.)

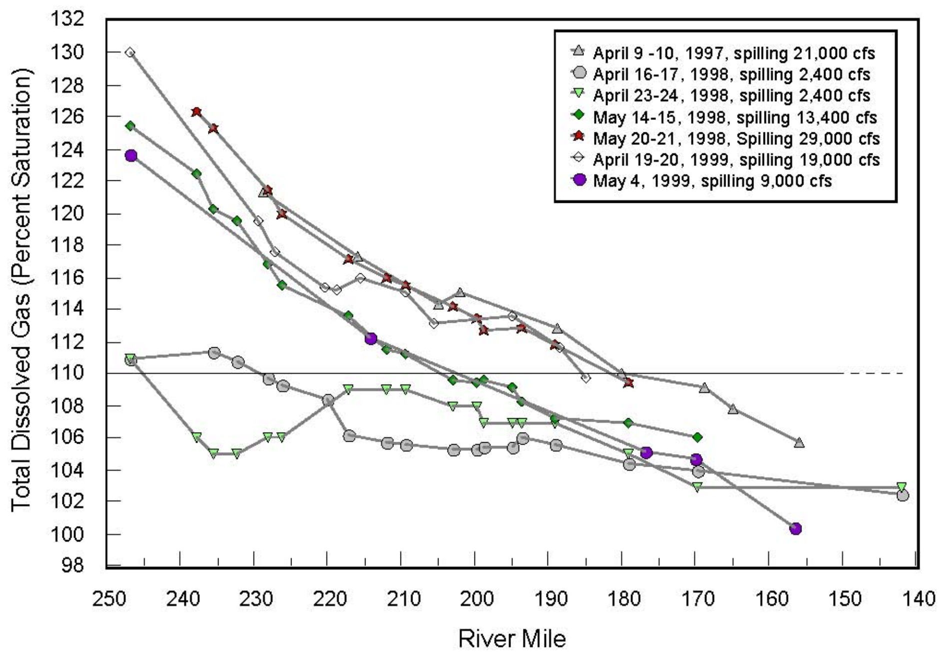


Figure 6.3-7
Downstream dissipation of TDG in the Snake River within Hells Canyon relative to the 110% saturation criterion. (Note: Add 30,500 cfs to spill to estimate the total Snake River flow. The TDG percent of saturation can be a combination of gas dissipation and mixing with turbine flows.)

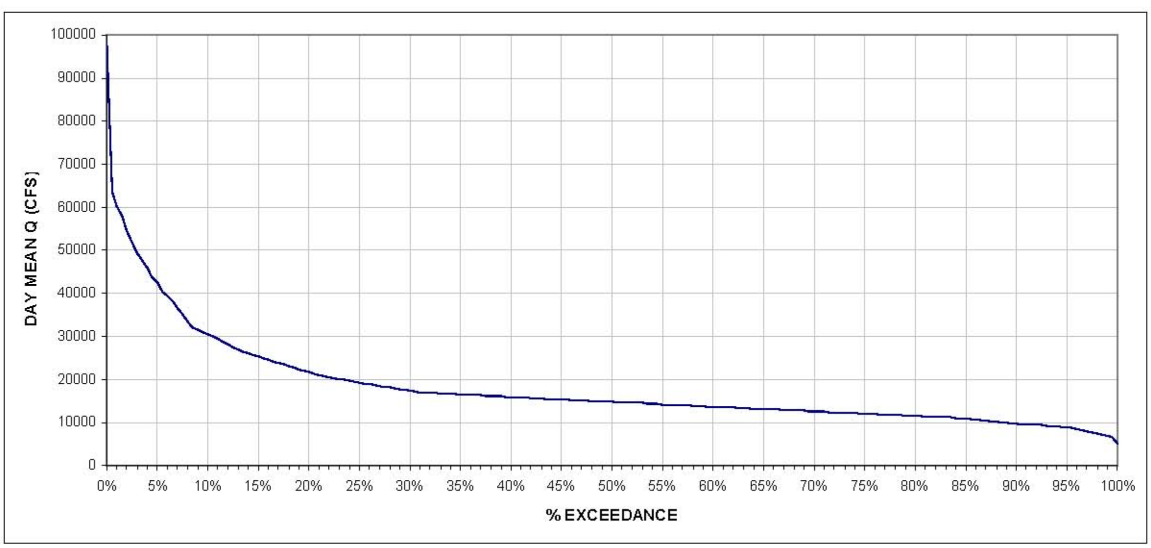


Figure 6.3-8
HCD daily average flow (day mean Q) in cfs flow-duration curve in percent of exceedance for the October 1968–February 2003 period of record

6.3.3. HCC Contribution to TDG

The SR–HC TMDL defined the load allocation for TDG as less than 110% of saturation at the edge of the aerated zones below Brownlee, Oxbow, and Hells Canyon dams (IDEQ and ODEQ

2004). The load applies to all flows not exceeding the 7Q10 average flood. The entire load was allocated to IPC because the SR–HC TMDL identified spill at Brownlee Dam and HCD as the sources of elevated TDG in the reach.

IPC recognizes that spillway releases from the HCC projects elevate TDG levels that have the potential for negative effects on aquatic life. External symptoms of gas-bubble trauma (GBT) have been observed on returning adult anadromous salmonids captured at HCD during periods of spill. These fish must migrate through the lower Columbia and Snake River hydroelectric projects on their way to HCD. The effects of Columbia River elevated TDG levels on fish have been well documented (McGrath et al. 2006).

No symptoms of GBT have been observed on juvenile SRFC salmon collected downstream of the HCC in sampling conducted by the U.S. Fish and Wildlife Service (FWS) (W. Connor, FWS, pers. comm.). The uppermost sampling location was approximately 20 miles downstream of HCD (RM 227.6). TDG levels measured near that location in April and May from 1997 through 1999 during spill over 9,000 cfs ranged from approximately 116 to 122% of saturation (Figure 6.3-7). The lack of GBT symptoms observed in juvenile SRFC salmon in Hells Canyon corroborated recent literature. McGrath et al. (2006) reviewed recent research on the effects of TDG levels on migratory juvenile and adult salmonids in the Columbia River. They concluded the newer research supports the previous research, indicating short-term exposure of up to 120% of saturation does not produce significant effects on migratory juvenile or adult salmonids when compensating depths are available. Weitkamp (2008) made a similar conclusion after summarizing the available literature from 1980 to 2007.

HCC resident fish were monitored for signs of GBT during spill in spring 2006 (Exhibit 6.3-1). GBT symptoms were observed only when TDG levels were greater than 120% of saturation within at least 12 hours prior to sampling. Severe GBT signs were observed when TDG exceeded 125% of saturation (daily average near 130%). Again, these results corroborated the research reviewed in McGrath et al. (2006) and Weitkamp (2008).

Under current operations, IPC minimizes spilling water. Therefore, further decreasing spill flow to manage TDG levels is not possible. Spilling water typically occurs only in association with high spring runoff events, USACE-mandated flood-control operations, or unplanned equipment failure.

6.4. Nuisance Algae

Algae are vitally important to freshwater ecosystems, and most species neither reach nuisance levels nor become harmful to human and animal health. Oregon has listed Brownlee Reservoir and the Snake River upstream as water-quality limited due to nuisance algal growths (Table 5.1-1). Idaho has listed similar waters as water-quality limited due to DO and TP (Table 5.1-2). The SR–HC TMDL presented data on excessive TP concentrations in the Snake River inflow to Brownlee Reservoir and reported nuisance algal growths have been routinely observed in the Snake River and the upper end of Brownlee Reservoir (IDEQ and ODEQ 2004). The IDEQ and ODEQ concluded the excessive nutrients were not wholly attributable to natural sources and established a 0.07-mg/L TP target, which correlated to a 14-µg/L average chlorophyll *a* concentration, for the protection of designated aquatic-life uses.

Additionally, a 30-µg/L nuisance threshold is not to be exceeded more than 25% of the time. Since water quality needed to protect aquatic life is likely more stringent than water quality needed to protect water supply and recreation uses, the targets were assumed to also be protective of these uses.

A harmful algal bloom (HAB) can occur when certain types of microscopic algae are present in high concentrations and produce toxic substances that harm people, pets, and livestock. HABs are most often caused by cyanobacteria. Cyanobacteria are a type of photosynthetic bacteria of the Cyanophyta taxon commonly referred to as blue-green algae. Cyanobacteria can grow as single-celled organisms, as a colony that may look like strands, or bunched together in mats or spherical clusters. When cyanobacteria begin to grow rapidly (e.g., when nutrients, temperature, pH, and light are conducive to exuberant growth) a cyanobacteria bloom can result. These blooms can appear as visible green, blue-green, or reddish brown foam, scum, or mats that float on or near the water surface. Depending on the species present, these blooms or the subsequent bloom die-off can be associated with toxins being present, representing a threat to human and animal health.

6.4.1. Nuisance Algae Criterion and Standards, SR–HC TMDL Targets, and HAB Guidance Levels

Oregon has numeric criterion for nuisance algal growths. Specifically, natural lakes that do not stratify, reservoirs, rivers, and estuaries may not exceed 15 µg/L (OAR 340-041-0019(1)(B)). Upon determination by the ODEQ that the criterion is exceeded, the ODEQ may conduct studies to describe water quality, determine the probable causes of the exceedance and beneficial-use impact, and develop a proposed control strategy for attaining compliance where technically and economically practicable (OAR 340-041-0019(2)(a)) (i.e., the ODEQ may develop a TMDL and water-quality management plan). Idaho has narrative criteria. Specifically, IDAPA 58.01.02.200.06 states, “waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.”

The SR–HC TMDL established a TP target not to exceed 0.07 mg/L (IDEQ and ODEQ 2004). This nutrient target correlated to a 14-µg/L chlorophyll *a* mean growing season (May through September) concentration that was established as the nuisance algae target. Further, chlorophyll *a* concentrations were not to exceed a nuisance threshold of 30 µg/L more than 25% of the time.

Since there is an SR–HC TMDL target and an Oregon numeric criterion for nuisance algal growths, IPC evaluated historic data to determine the most stringent of the two. Using historic data, IPC evaluated the reduction needed to lower the maximum chlorophyll *a* measured in the Snake River inflow to Brownlee Reservoir to the Oregon numeric criterion for nuisance algal growths of not to exceed 15 µg/L. The needed percent reduction was then equally applied to all the historic measured values. Comparing the mean growing season concentrations indicated that if chlorophyll *a* was reduced sufficiently to meet Oregon’s criterion, the SR–HC TMDL target of 14 µg/L would also be met. The conclusion is that Oregon’s criterion is more stringent than the SR–HC TMDL TP target not to exceed 0.07 mg/L, which correlated to a 14-µg/L chlorophyll *a* mean growing season (May through September) concentration that was established as the nuisance algae target (IDEQ and ODEQ 2004). Therefore, IPC evaluated data relative to the Oregon numeric criterion for nuisance algal growth of not to exceed 15 µg/L.

The Oregon Health Authority Public Health Division (OPHD) has cyanotoxin guideline values for issuing and lifting public health advisories when HABs are detected (Table 6.4-1). Currently, the IDHW has no HAB action levels.

Table 6.4-1
Provisional health-based guideline values in µg/L for cyanotoxins in Oregon's recreational waters (OPHD 2015a)

Anatoxin-a	Cylindrospermopsin	Microcystin	Saxitoxin
20	6	10	10

6.4.2. Conditions Relative to Nuisance Algae and HABs

Nuisance algal growths are often defined by chlorophyll *a* concentration or cell density; however, certain algae, for example blue-green algae, have been identified as having possible harmful effects. The following sections discuss conditions relative to both concentration and community structure.

The OPHD and IDHW issue public health advisories. Neither Oregon nor Idaho has issued HAB advisories for the HCC through the 2014 water year (OPHD 2014; IDHW 2014).

6.4.2.1. Algal Biomass

Algal biomass is often estimated using chlorophyll *a* measures. Because algal cell volumes and weights vary by orders of magnitude (Reynolds 1984), biomass estimates can indicate different trends compared to density measurements (e.g., high densities in areas with low biomass).

Chlorophyll *a* measured in the Snake River immediately upstream of Brownlee Reservoir (RM 345.6) and in the inflow to the reservoir (RM 335 to 340) indicated nuisance algal growths. This corroborated routine observations as reported in the SR–HC TMDL of nuisance algal growth in the Snake River and the upper end of Brownlee Reservoir (IDEQ and ODEQ 2004). Figure 6.4-1 illustrates the 15-µg/L chlorophyll *a* criterion was exceeded nearly two-thirds of the time, and the SR–HC TMDL nuisance threshold of 30 µg/L was exceeded about 40% of the time between 2002 and 2014 in the Snake River immediately upstream of Brownlee Reservoir (RM 345.6). Median chlorophyll *a* concentrations during 2002 (Figure 6.4-2) were comparable to those measured in the inflow to Brownlee Reservoir (RM 335–340). The difference in the median values were not statistically different (P = 0.383). It may be assumed that median chlorophyll *a* concentrations in the Snake River are similar to those measured in the inflow to the Brownlee Reservoir.

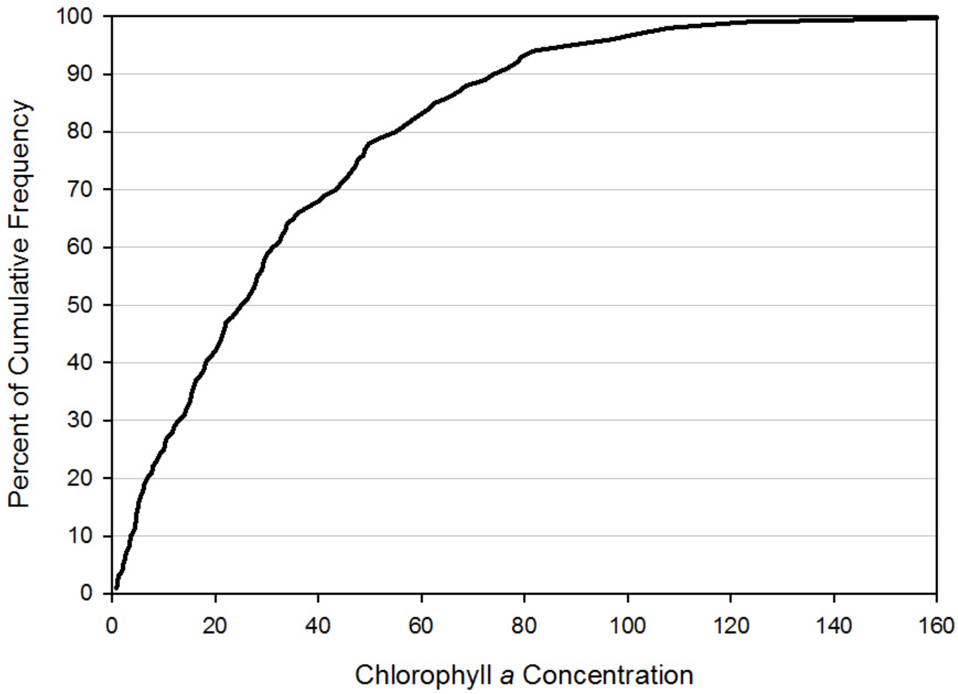


Figure 6.4-1
The percent of cumulative frequency for chlorophyll *a* concentrations in µg/L collected from 2002 through 2014 from the Snake River immediately upstream of Brownlee Reservoir (RM 345.6; N = 333)

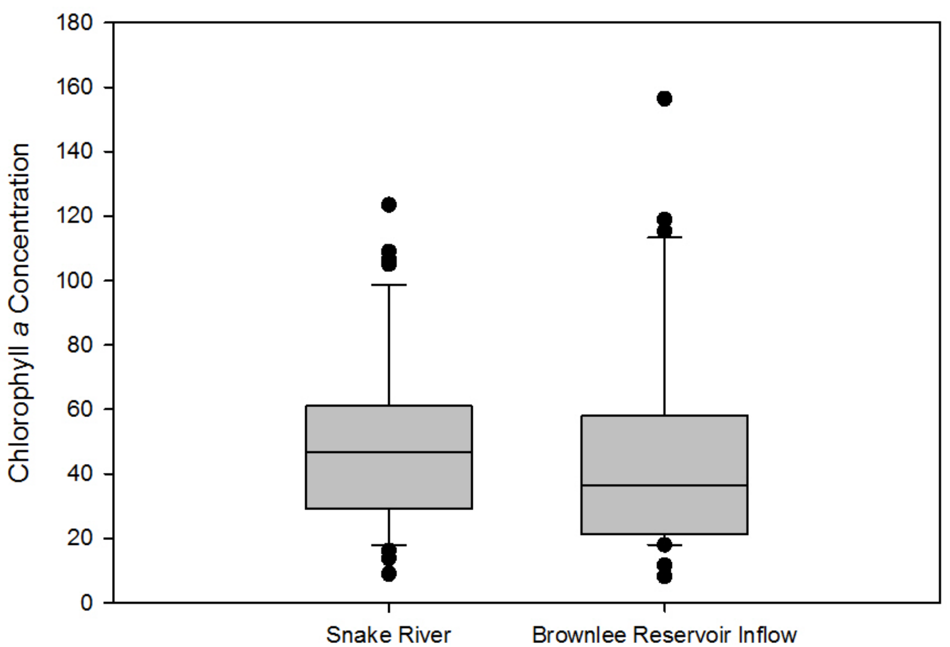


Figure 6.4-2
Interquartile ranges (the box represents the median and the 75th and 25th percentiles; the lines represent the 90th and 10th percentiles) for chlorophyll *a* concentrations in µg/L from the Snake River immediately upstream of Brownlee Reservoir (RM 345.6; N = 43) and in the Brownlee Reservoir inflow (RM 335–340; N = 33) during 2002

Brownlee Reservoir chlorophyll *a* surface measurements (i.e., less than 2.5 m) showed a general decreasing trend from the riverine zone (approximately RM 334 to RM 324) through the transition zone (approximately RM 324 to RM 308) and into the lacustrine zone (Figure 6.4-3). Low chlorophyll *a* concentrations were thereafter maintained downstream throughout the HCC. A maximum chlorophyll *a* concentration of 3,637 µg/L was measured on August 14, 2002, at RM 325. This value was determined to be valid based on the reported pheophytin *a* concentration and the Optical Density ratio of 664 to 665 nanometer light (APHA 1999). This value likely represents sampling of an algal bloom occasionally observed in this area.

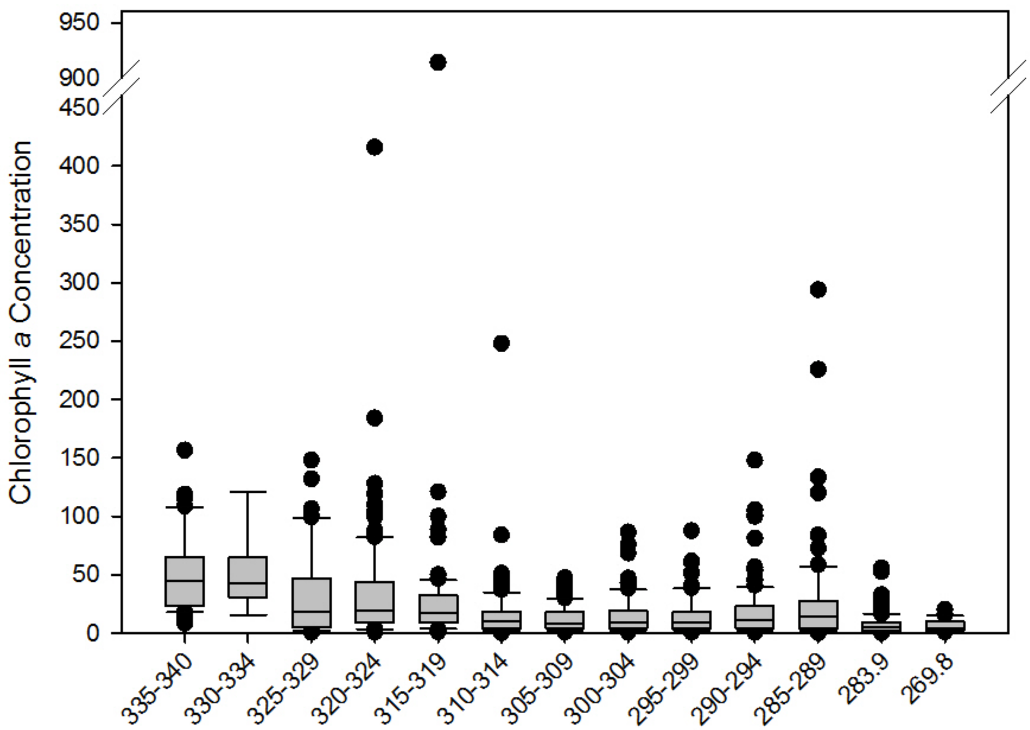


Figure 6.4-3
Interquartile ranges (the box represents the median and the 75th and 25th percentiles; the lines represent the 90th and 10th percentiles) for surface chlorophyll *a* concentrations in µg/L measured year-round from 2002 through 2014, throughout the HCC. The x-axis represents river miles grouped into 5-mile intervals. Concentrations at RM 283.9 represent inflow to Oxbow Reservoir and RM 269.8 represent inflow to Hells Canyon Reservoir.

While much reduced relative to the upper end of Brownlee Reservoir, elevated chlorophyll *a* concentrations (i.e., relative to the criterion) persist through to the discharge of the HCC. While not as frequent as in the Snake River immediately upstream of Brownlee Reservoir, chlorophyll *a* concentrations in the HCC discharge (RM 247) exceeded the 15-µg/L numeric criterion about 7% of the time, and rarely (<1% of the time) was the SR–HC TMDL nuisance threshold of 30 µg/L exceeded between 2002 and 2014 (Figure 6.4-4).

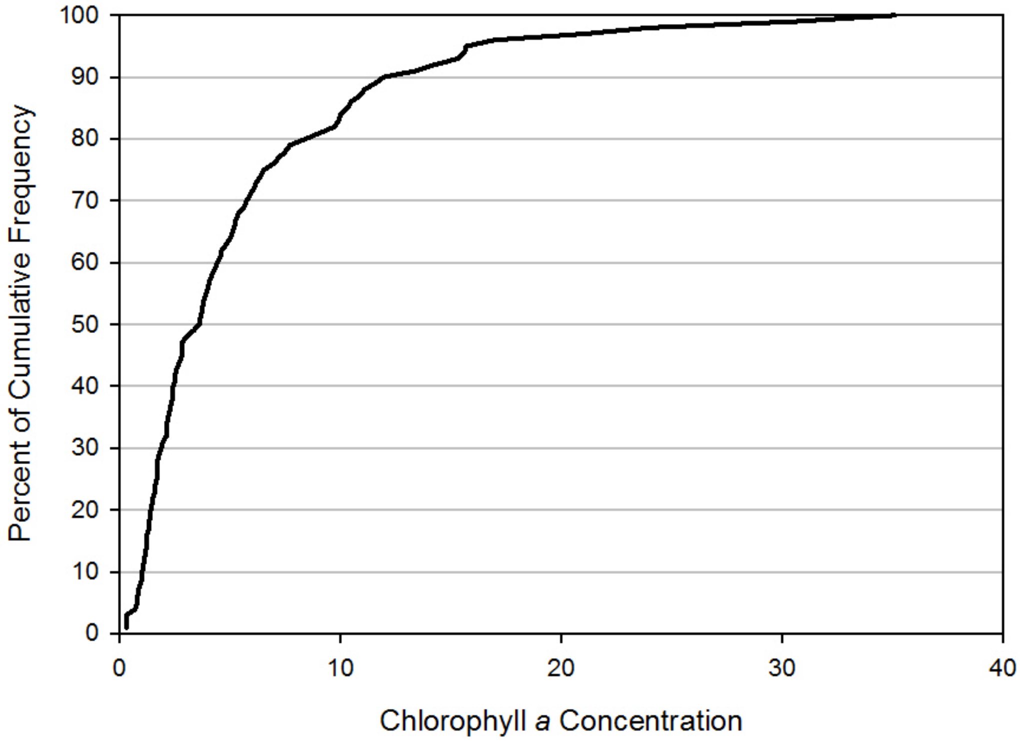


Figure 6.4-4
The percent of cumulative frequency for chlorophyll *a* concentrations in µg/L collected from 2002 through 2014 from the Snake River immediately downstream of the HCC (RM 247; N = 133)

6.4.2.2. Algal Communities

Chrysophyta taxa, originally including all forms of diatoms and multicellular brown algae, dominated spring assemblages throughout the HCC during 1993 and 1994, with the highest algal cell densities in the upper section of Brownlee Reservoir from RM 305 to RM 329 (Myers et al. 2003). More detail on algal communities of the HCC reservoirs is available in Technical Report E.2.2-2 of the *New License Application: Hells Canyon Hydroelectric Complex*. An assemblage shift occurred from spring to summer, resulting in heavy dominance by blue-green algae; predominately the species *Aphanizomenon flos-aquae*. High densities of blue-green algae were measured in Brownlee Reservoir at RM 285 and RM 290 during August 1991 and again in Brownlee Reservoir at RM 320 and in Hells Canyon Reservoir at RM 249 during the summer of 1993 and 1994. In the fall, a general assemblage shift back to Chrysophyta taxa was observed throughout the HCC, with the highest densities in the upper section of Brownlee Reservoir. However, blue-green algae still were dominant lower in Brownlee Reservoir at RM 312 and RM 302. This corroborated observations reported in the SR–HC TMDL of diatom species dominating in faster-moving water with less stratification and blue-green algae species becoming more prevalent as water slowed (IDEQ and ODEQ 2004).

6.4.2.3. Harmful Algae Blooms

Thick surface scums of blue-green algae have been observed in the upper end of Brownlee Reservoir, especially in low water years. *Aphanizomenon flos-aquae* is a species of blue-green algae commonly found in fresh waters. OPHD (2015a) reported that although some studies have shown this species to produce toxins in other parts of the world, subsequent evaluations of that work show the species either was or likely was misidentified. Further, they stated *Aphanizomenon flos-aquae* is excluded from calculation of combined cell counts of toxigenic species for the purpose of issuing public health advisories.

IPC enumerated algal cell density in the HCC during 1993 and 1994. Table 6.4-2 provides the mean cell density for cynaobacteria excluding *Aphanizomenon flos-aquae.* None of the cumulative toxigenic cyanobacteria cell densities exceeded the Oregon Health Authority (OHA) guideline of greater than 100,000 cells/ml; therefore, harmful algae blooms were likely not a concern in the HCC.

Table 6.4-2
Toxigenic cyanobacteria mean density in cells per ml for Brownlee, Oxbow, and Hells Canyon Reservoirs in 1993 and 1994

	Brownlee			Oxbow			Hells Canyon		
	April	July	October	April	July	October	April	July	October
Anabaena flos-aquae	7	329	0	0	0	0	0	645	0
Anabaena spiroides	0	149	0	0	44	0	0	77	0
Oscillatoria sp.	0	0	0	0	0	1	0	0	0
Oscillatoria geminata	0	715	0	0	75	0	0	418	13
Oscillatoria limnetica	0	0	120	0	0	0	0	0	12
Microcystis aeruginosa	0	0	0	0	0	0	0	0	0
Phormidium mucicola	0	0	0	0	0	0	0	0	0
Total	**7**	**1,193**	**120**	**0**	**119**	**1**	**0**	**1,140**	**25**

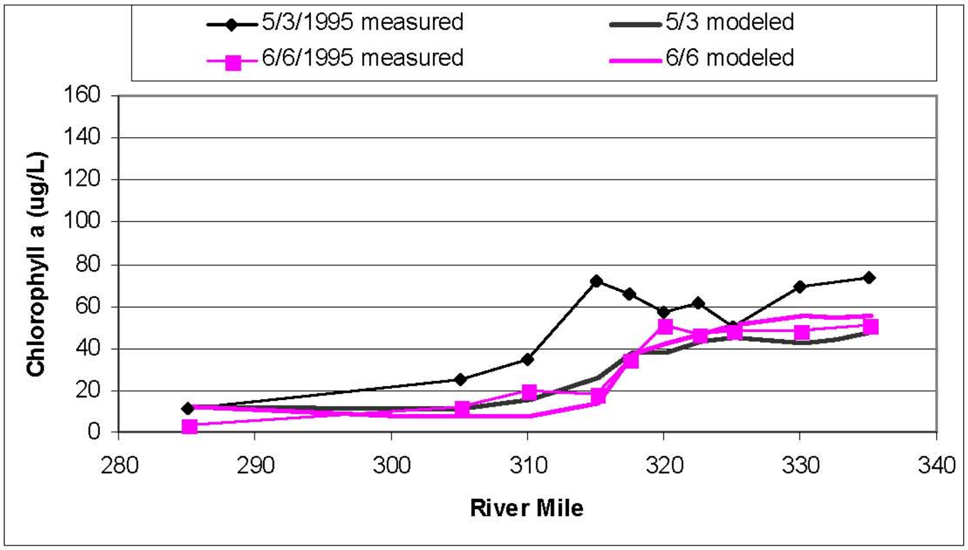
6.4.3. HCC Contribution to Nuisance Algae and HABs

6.4.3.1. Modeling Algae in Brownlee Reservoir

CE-QUAL-W2 (Cole and Wells 2002), a 2-dimensional model, was used to assess algal biomass in Brownlee Reservoir. Version 3.1 allows for model applications with multiple algal groups; however, estimating boundary conditions and optimizing performance requires considerable data and effort. For example, modeling community shifts under SR–HC TMDL conditions would require some estimate of the community shift in the Snake River inflow to Brownlee Reservoir. The current Brownlee Reservoir model application has not been set up and optimized for multiple groups because of this added complexity. Instead, available data and literature were used to predict shifts in the algal community structure with full implementation of the SR–HC TMDL.

6.4.3.1.1. CE-QUAL-W2 Algal Biomass Simulations with SR–HC TMDL Implementation

The CE-QUAL-W2 model simulated Brownlee Reservoir algae with full implementation of the SR–HC TMDL. This included reducing nutrients and organic matter inflow to Brownlee Reservoir (approximately 69% reduction in TP, nitrogen, and organic matter) and reducing SOD (set at 0.1 g of oxygen per m^2 per day). Selected simulation conditions from the optimized model showed predicted algal biomass compared to measured data (Figure 6.4-5). The model predicted chlorophyll *a* concentrations well on June 6, 1995; under-predicted concentrations on both May 3, 1995, and August 9, 1995; and over-predicted concentrations in the upper end of the transition zone on July 5, 1995. Simulated conditions indicated the model represented general algal processes, as indicated by dynamic algal biomass estimates, not just settling (Figure 6.4-6). These processes were illustrated by increased concentrations downstream of the inflow and reduced concentrations further downstream.



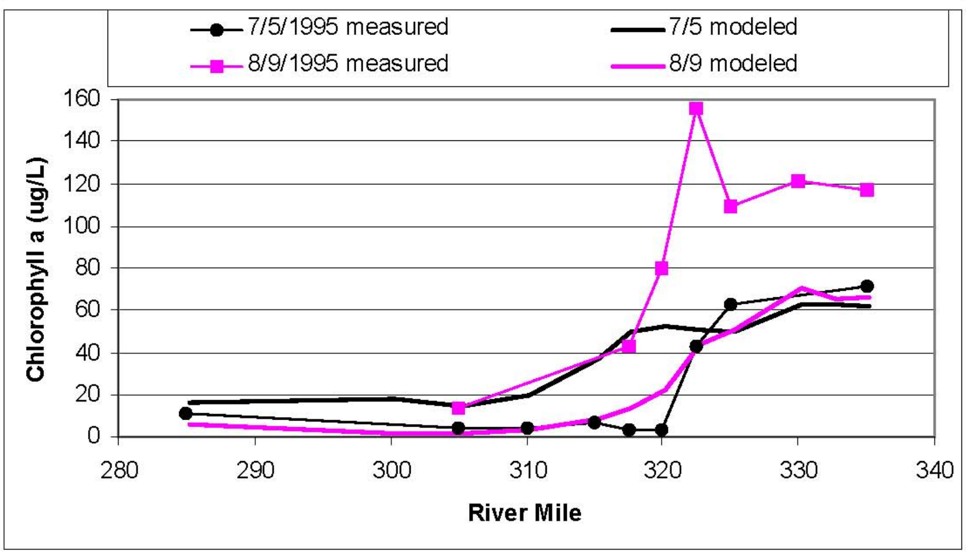


Figure 6.4-5
Baseline simulation results showing modeled and measured chlorophyll *a* concentrations in µg/L in the surface layer of Brownlee Reservoir for selected dates in 1995

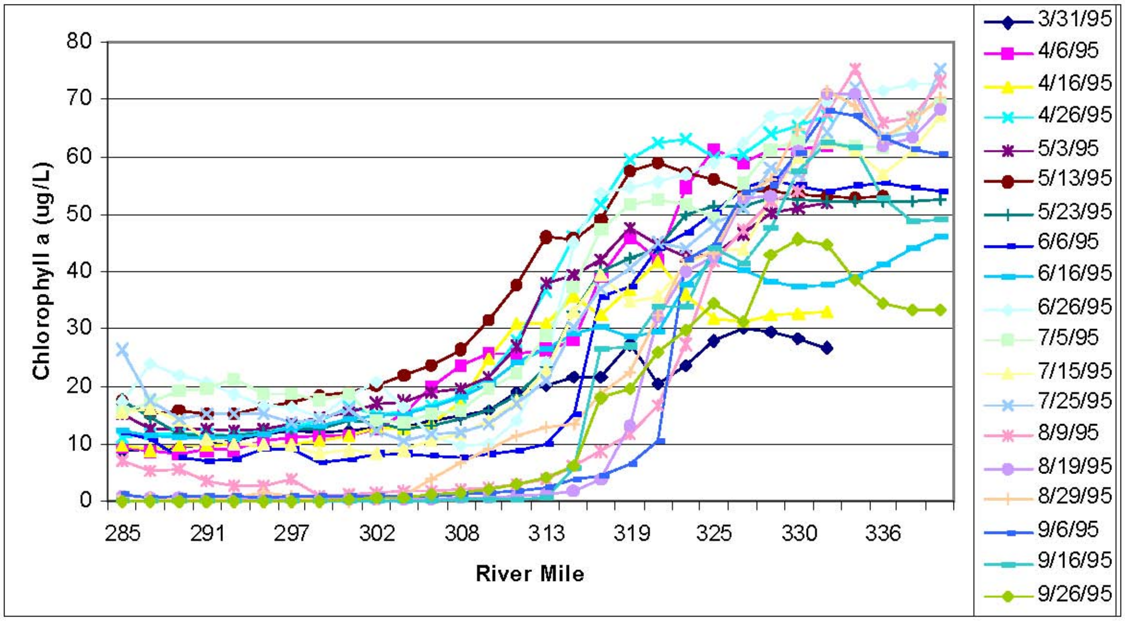


Figure 6.4-6
Modeled surface chlorophyll *a* concentrations in µg/L in Brownlee Reservoir from March 31–September 26, 1995

6.4.3.1.2. Predicted Algal Community Structure

Diatoms tend to dominate in more riverine conditions, especially in the spring. In eutrophic systems, blue-green algae tend to dominate in lower-velocity waters, like the lacustrine zone, with taxa, such as *Microcystis*, *Anabaena*, and *Aphanizomenon*, forming blooms in still, windless conditions (Reynolds 1984). This is caused partly by differences in density and buoyancy. However, Webb (1964) concluded that the Snake River above Brownlee Reservoir carried heavy loads of organic matter in the form of suspended algae, dominated by blue-green algae (*Anabaena*, *Pediastrum*, *Spirogyra*, *Aphanizomenon*, *Staurastrum*, and *Anacystis*), that were produced in the 120-mile reach upstream of Brownlee Reservoir. Worth (1994) observed *Anabaena* and *Microcystis* in the Snake River above Brownlee Reservoir in 1992.

Potential changes in Brownlee Reservoir algal taxa after implementation of the SR–HC TMDL would depend partly on changes that occurred upstream in the Snake River. Because these changes are highly speculative and would have to be set in the model as boundary conditions, algal taxa shifts in Brownlee Reservoir cannot be fully modeled.

6.4.3.2. Nuisance Algae and HAB Reasonable Assurance

The SR–HC TMDL did not establish nuisance algae allocations (IDEQ and ODEQ 2004). Rather, the SR–HC TMDL presented an analysis that develops a TP target of 0.07 mg/L to attain the mean growing season chlorophyll *a* target of 14 µg/L and a nuisance threshold of 30 µg/L, not to be exceeded more than 25% of the time, for the Snake River and the HCC. The Snake River TP target provides reasonable assurance the upstream boundary will not exceed the chlorophyll *a* target and threshold levels, and the community structure will shift toward less problematic taxa (e.g., blue-green algae) and, therefore, a reduced risk of HABs.

The optimized CE-QUAL-W2 model was used to simulate full implementation of the SR–HC TMDL. The simulations showed maximum chlorophyll *a* concentrations would be less than 30 µg/L (Figure 6.4-7). This was consistent with the conclusions in the SR–HC TMDL that state "…the 0.07 mg-TP/L target will eliminate the large peaks in chlorophyll *a* observed in the upper part of the reservoir" (IDEQ and ODEQ 2004). May through September average concentrations were as high as approximately 20 µg/L through the transition zone. More importantly, chlorophyll *a* concentrations did not increase in Brownlee Reservoir. It is expected that if the 14 µg/L chlorophyll a target was met at the inflow to Brownlee Reservoir, chlorophyll *a* concentrations would not exceed the target in the reservoir.

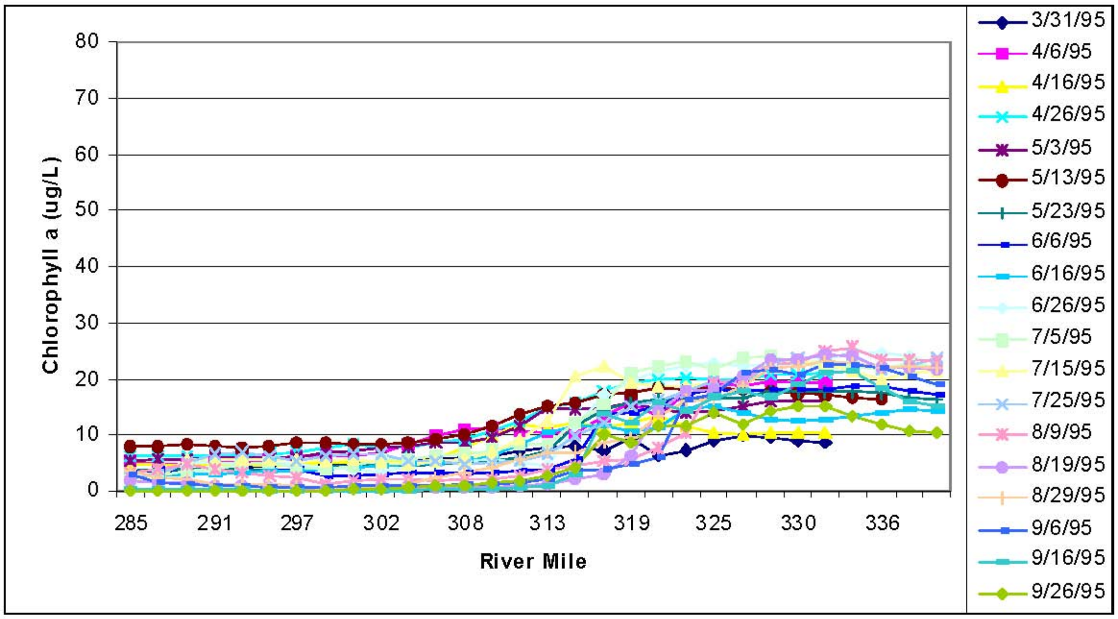


Figure 6.4-7
Modeled surface chlorophyll *a* concentrations in µg/L in Brownlee Reservoir from March 31–September 26, 1995, with full SR–HC TMDL implementation

Further, IPC evaluated data from both impounded and unimpounded waters of the Snake River to determine nuisance chlorophyll *a* concentration thresholds and targets. IPC's findings indicated a nuisance threshold of approximately 30 µg/L and a target between 15 µg/L and 20 µg/L would provide reasonable assurance that designated beneficial uses would be protected in the southwest Snake River and Brownlee Reservoir (Hoelscher 2002). This corroborated with the CE-QUAL-W2 model simulated conditions.

Reduced algae levels following full implementation of the SR–HC TMDL are reasonably assured to protect beneficial uses in the Snake River and the HCC. Lower nutrient loads could result in a shift from blue-green algae to green algae (or other groups) during the summer; however, changes in the HCC algal taxa would depend partly on changes that occurred upstream in the Snake River. Because these changes are highly speculative and would have to be set in the model as boundary conditions, algal taxa shifts in Brownlee Reservoir cannot be fully modeled. Therefore, IPC's proposal includes measures to monitor algal community structure and HABs during recreational periods throughout the HCC as described in Section 7.4. HAB Proposed Measures.

6.5. pH

Oregon has not listed pH as a pollutant limiting the mainstem Snake River (Table 5.1-1). Idaho originally listed Brownlee Reservoir water quality as impaired by pH, as well as the Snake River upstream to the Oregon and Idaho border. As a result of the SR–HC TMDL analysis, Idaho removed pH from the CWA § 303(d) list (Table 5.1-2). The SR–HC TMDL concluded pH CWA § 303(d) listings are not supported by the available data (IDEQ and ODEQ 2004):

> Based on these findings, the SR–HC TMDL process recommends that the mainstem Snake River from RM 409 to 347 and from RM 335 to 285 [Brownlee Reservoir] be delisted for pH by the State of Idaho.

6.5.1. pH Standards and SR–HC TMDL Targets

Oregon's criteria for pH in the mainstem Snake River basin are 7.0 to 9.0 SUs (OAR 340-041-0124). However, waters impounded by dams existing on January 1, 1996, having pH values that exceed the criteria are not in violation of the standard if the ODEQ determines the exceedance would not occur without the impoundment, and all practicable measures have been taken to bring the pH in the impounded waters into compliance (OAR 340-0410-0021(2)). Idaho's criteria for pH in fresh waters are 6.5 to 9 SUs (IDAPA 58.01.02.250.01.a.).

A pH range of 7 to 9 SUs has been established as the target for the SR–HC TMDL to support aquatic life (IDEQ and ODEQ 2004). This target applies year-round from RM 409 throughout the HCC to RM 188.

6.5.2. Conditions Relative to pH

Most of the pH concentrations measured throughout the HCC were within the SR–HC TMDL target range of 7 to 9 SUs (Figure 6.5-1). Values less than 7 SUs were less common than values greater than 9 SUs (Table 6.5-1). This corroborated the SR–HC TMDL findings that the lowest pH value observed in Brownlee Reservoir was 7.4 SUs, while the highest was 9.6 (IDEQ and ODEQ 2004). Almost all pH measures were within the target range in Oxbow Reservoir, while exceedances increased slightly in Hells Canyon Reservoir.

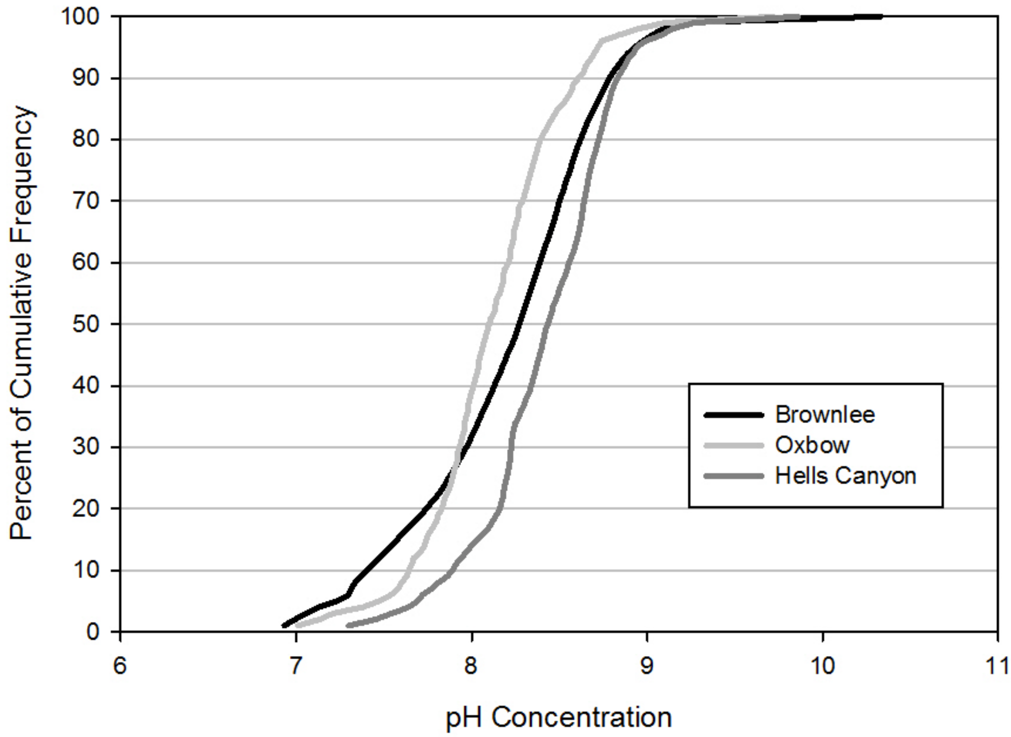


Figure 6.5-1
Percent of cumulative frequency curves for pH concentration in SUs as measured in Brownlee, Oxbow, and Hells Canyon reservoirs from 1990 through 2014

Table 6.5-1
Percent exceedance of pH concentration measures in SUs for the Snake River upstream of the HCC; Brownlee, Oxbow, and Hells Canyon reservoirs; and the HCC discharge from 1990 through 2014

		Percent of pH Concentration Measures		
	N	**Less Than 7**	**Greater Than 9**	**Total**
Snake River Upstream	1,080	1.1	17.6	18.7
Brownlee Reservoir	134,062	2.1	3.5	5.6
Inflow	512	1.8	12.1	13.9
Riverine	3,800	1.5	14.2	15.7
Transition	33,964	2.1	6.5	8.6
Lacustrine	96,056	2.2	2.0	4.1
Oxbow Reservoir	1,604	0.7	1.6	2.3
Hells Canyon Reservoir	15,910	0.1	3.9	4.0
Snake River Downstream	815	2.3	1.2	3.5

Brownlee Reservoir receives inflowing water from the Snake River, and the frequency of pH concentrations above and below the target range was similar in the inflow and riverine zones to the Snake River upstream (Figure 6.5-2). The other zones of Brownlee Reservoir had exceedances of the target range (Table 6.5-1), although they were less than 10% of the measurements, and the frequency of exceedance decreased with both distance and depth from the Snake River inflow. Overall, pH concentrations were moderated through the HCC as illustrated by the substantially lower level of values outside the target range in the Snake River immediately downstream of the HCC as compared to the Snake River upstream (Figure 6.5-3).

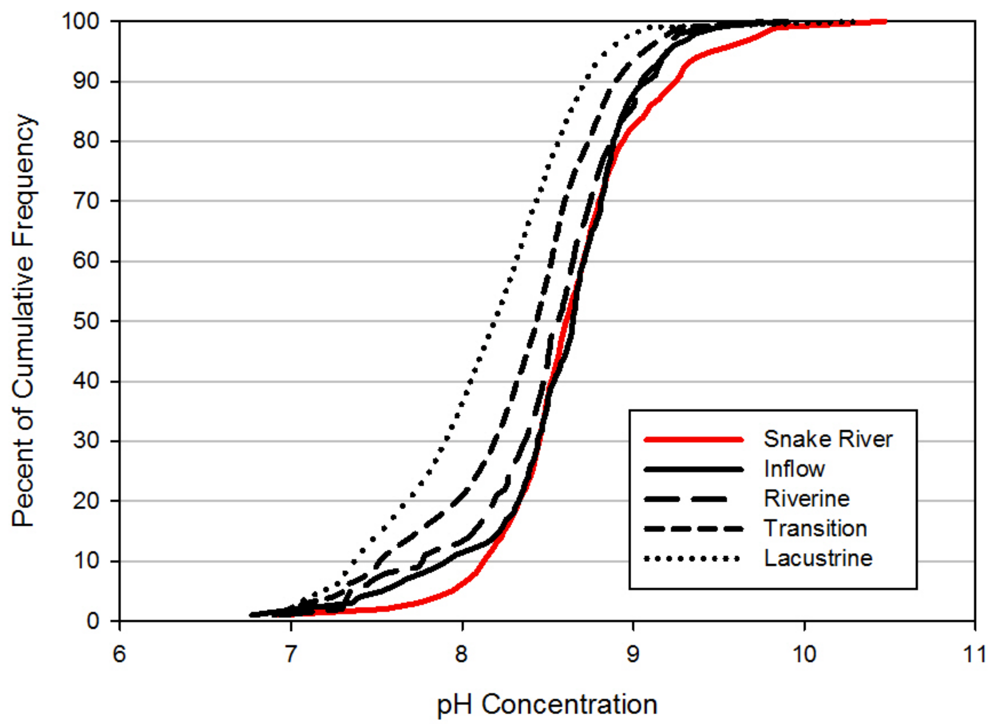


Figure 6.5-2
Percent of cumulative frequency curves for pH concentration in SUs in the Snake River immediately upstream of Brownlee Reservoir and throughout the reservoir zones from 1990 through 2014

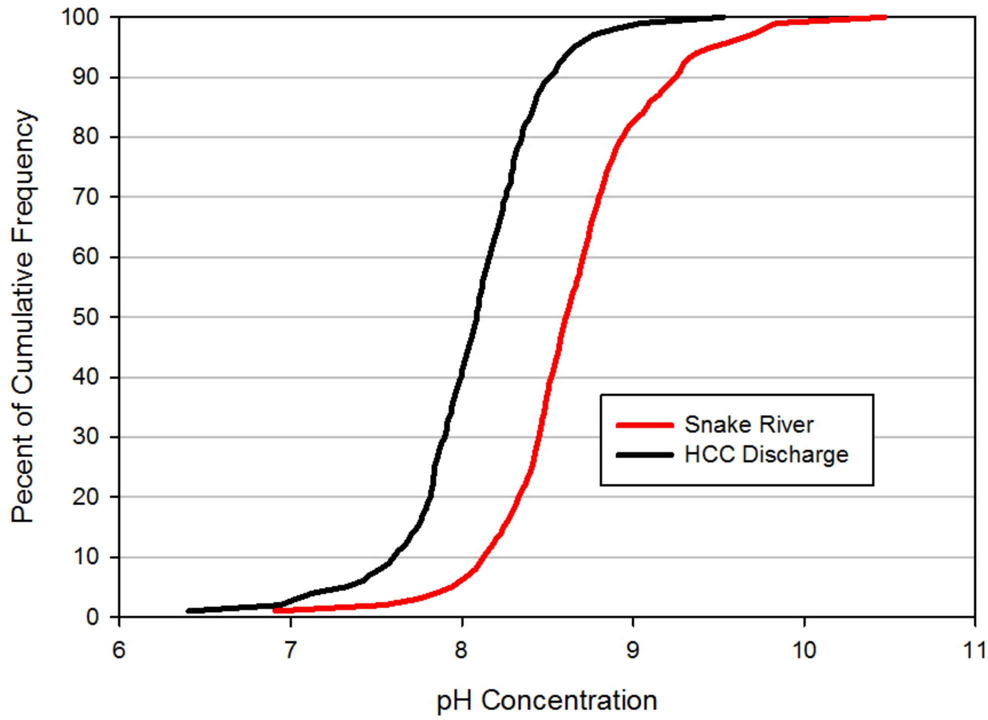


Figure 6.5-3
Percent of cumulative frequency curves for pH concentration in SUs as measured in the Snake River immediately upstream of the HCC and in the Snake River downstream from 1990 through 2014

6.5.3. HCC Contribution to pH

The pH of natural waters is governed to a large extent by the interaction of hydrogen ions (H+) arising from the dissociation of carbonic acid (H_2CO_3) and hydroxide ions (OH^-) produced during the hydrolysis of bicarbonate (HCO_3^-). Carbonic acid formed from the hydration of dissolved carbon dioxide (CO_2) solubilizes calcium-rich rock, producing calcium bicarbonate ($Ca(HCO_3)_2$) that exists in solution (as Ca^{2++} and HCO_3^-) in equilibrium with carbon dioxide ($H_2CO_3^-$) and carbonate ion (CO_3^{2-}). When this equilibrium is disrupted by the removal of carbon dioxide, calcium bicarbonate enters into another important equilibrium reaction resulting in the precipitation of calcium carbonate ($CaCO_3$) (Wetzel 2001). Evidence of calcium carbonate precipitation is commonly seen on substrate in the Snake River (e.g., white calcium carbonate deposits [marl] on the rocks).

These reactions increase the pH concentration when carbon dioxide is removed during photosynthesis. Wetzel (2001) stated the rate of calcium carbonate precipitation is slow unless increases are induced by photosynthetic carbon dioxide removal. When the rate of precipitation is rapid, it results in a temporary supersaturation of calcium and bicarbonate. To maintain equilibrium, supersaturated bicarbonate reacts with hydrogen ions to form carbonic acid and dissociates to release hydroxide ions. Both of these reactions (i.e., a decrease in hydrogen or an increase in hydroxide) increase pH.

In addition to the above process, pH change can be affected through changes in alkalinity following nutrient assimilation during photosynthesis. Since alkalinity is associated with a charge balance, the assimilation of ammonium (NH_4^+), nitrate (NO_3^-), and hydrogen phosphate ion (HPO_4^{2-}) ions are accompanied by the uptake or release of hydrogen and hydroxide ions through alkalinity changes (Stumm and Morgan 1995). Therefore, the assimilation of ammonium, nitrate, and hydrogen phosphate ion is accompanied by the assimilation of hydrogen ions, lowering the hydrogen ion concentration and increasing pH.

In summary, 2 key biochemical processes occurring in the Snake River are associated with photosynthesis that cause pH to increase 1) the removal of carbon dioxide (inorganic carbon) occurring when algae grow and 2) the removal of nutrients also occurring when algae grow.

Exceedance of the pH targets in the HCC appears related to inflowing Snake River water with elevated primary productivity. Data collected in the Snake River upstream of Brownlee Reservoir (RM 345.6) indicated that as chlorophyll *a* increased (a surrogate for algal biomass), the pH concentration also increased (Figure 6.5-4). A linear regression of these data showed, when daily average chlorophyll *a* concentrations were greater than 60 µg/L—a common occurrence in the Snake River inflow to Brownlee Reservoir—daily average pH values were above the 9 SU target. The SR–HC TMDL set a chlorophyll *a* target of 14 µg/L, with a nuisance threshold of 30 µg/L not to be exceeded more than 25% of the time (IDEQ and ODEQ 2004). Daily average pH levels are predicted to drop to approximately 8.6 SUs when chlorophyll *a* concentrations are near the SR–HC TMDL nuisance threshold target and are predicted to be slightly lower when the 14 µg/L target is achieved.

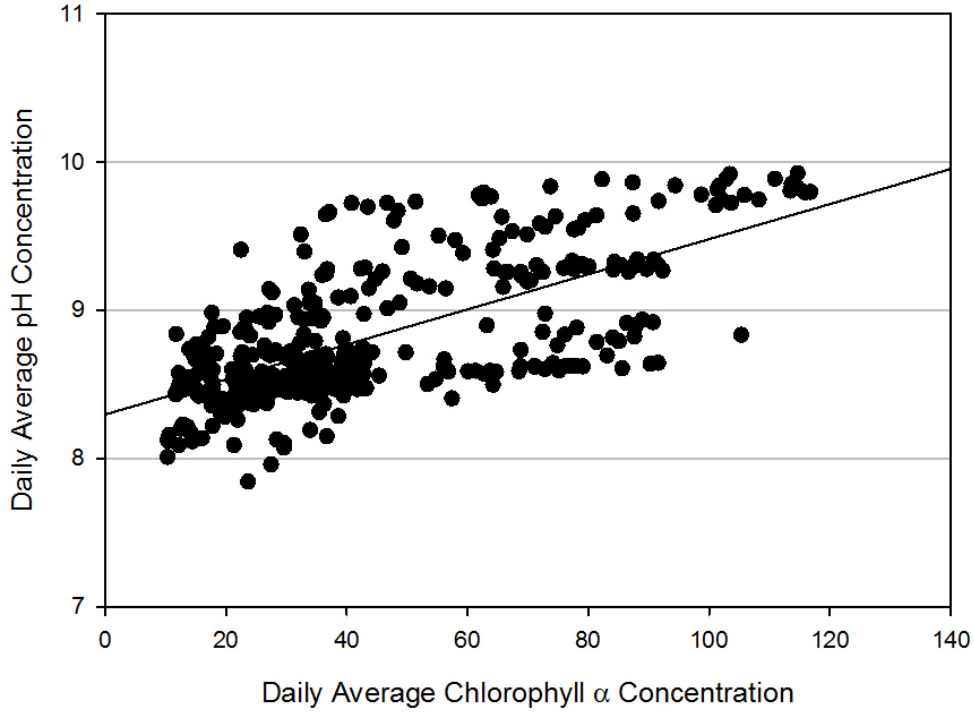


Figure 6.5-4
Upstream Snake River linear regression (R^2 = 0.4678) for daily average pH concentration in SUs and daily average chlorophyll *a* concentration in µg/L, as calculated using a chlorophyll *a* concentration and relative fluorescence unit correlation, at RM 345.6 for data collected from April 2002–July 2003

The variability and relatively low correlation evident in the chlorophyll *a* and pH regression is due to natural variability and the presence of other factors that contribute to pH changes, such as the alkalinity, reaeration rate (related to velocity and depth), algal growth rate (varies by season and daily climatic conditions), and benthic productivity (photosynthesis by periphyton and macrophytes). Benthic productivity may be a primary source of variability in the relationship between water-column chlorophyll *a* and pH. Periphyton and attached macrophytes are abundant in the Snake River upstream of Brownlee Reservoir, especially during low water conditions. The SR–HC TMDL noted that reductions in attached periphyton and macrophyte growth were anticipated with the implementation of the TP target (IDEQ and ODEQ 2004).

6.5.3.1. Modeling pH

Various models are available to simulate pH in natural systems. Most models are based on the equilibrium chemistry for carbonate systems, as discussed in Section 6.5.3. HCC Contribution to pH. Among these, a simplistic mass balance model (Chapra 1997) and the more sophisticated CE-QUAL-W2 model (Cole and Wells 2002) were used to demonstrate the link between elevated algal biomass and high pH. The CE-QUAL-W2 model, being a 2-dimensional model, requires additional information, including initial boundary conditions and assumptions regarding alkalinity and total inorganic carbon (TIC). The importance of knowing initial boundary conditions and assumptions will also be demonstrated.

6.5.3.1.1. Mass Balance Model

The mass balance model assumes TIC varies due to respiration, photosynthesis, and atmospheric exchange (Chapra 1997). Respiration and photosynthesis, respectively, increase or decrease the carbon dioxide in solution. Based on this change, atmospheric exchange occurs at rates proportional to a transfer coefficient proportional to the transfer coefficient for oxygen. Because atmospheric exchange lags respiration or photosynthesis, there is a net increase or decrease in TIC, producing a local equilibrium. A steady-state pH is calculated for any alkalinity after the new TIC is known. This is referred to as steady-state pH based on the local equilibrium assumption that reactions between inorganic carbon species are faster than atmospheric and biotic reactions. The steady-state pH would represent the maximum pH when photosynthesis rates are at peak levels.

The mass balance model was used to estimate pH for various rates of photosynthesis and 2 levels of alkalinity. Results from the mass balance model indicated lower rates of photosynthesis produced lower steady-state pH values (Figure 6.5-5). The model also showed that changes in alkalinity affected steady-state pH. Snake River data reported by the USGS (2003) showed alkalinity can range from 100 to 200 mg/L (as calcium carbonate). This was comparable to the 2 to 4 micro equivalent per liter curves shown for the mass balance analysis. As stated previously, algae growth can induce changes in alkalinity through the removal of nutrient ions (i.e., the assimilation of nitrate and hydrogen phosphate). Lower nutrient-removal rates and pH values would be anticipated with lower rates of photosynthesis through the implementation of the nutrient TMDL.

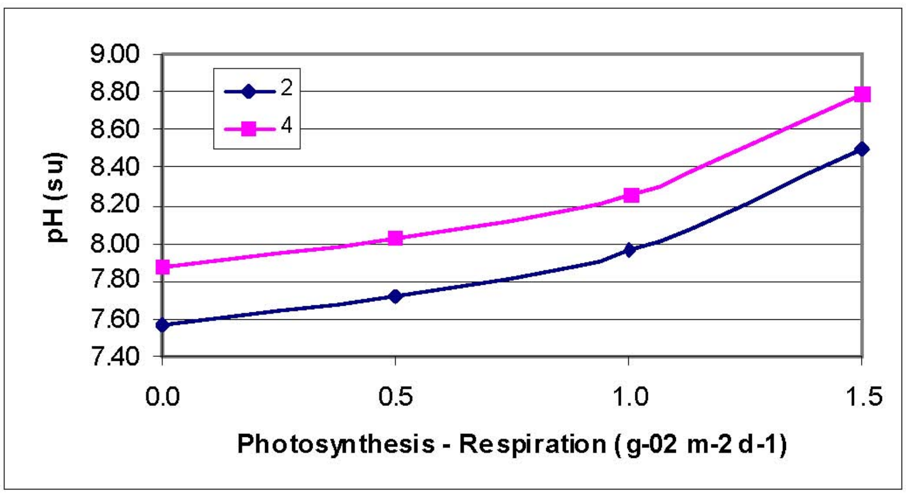


Figure 6.5-5
Modeled steady-state pH values in SUs at photosynthesis-dominated rates and 2 rates of alkalinity in micro-equivalents per liter. (Note: 1 micro-equivalent per liter is equal to 50 mg/L as calcium carbonate). The initial conditions assume TIC levels have increased due to respiration at 1.5 grams of oxygen per m^2 per day (g-02 m-2 d-1). Model based on Chapra (1997).

6.5.3.1.2. CE-QUAL-W2 Model

The CE-QUAL-W2 model algorithms for pH are based on a total carbon balance and carbon dioxide equilibrium with the atmosphere (Cole and Wells 2002). The model applies the following assumptions when modeling pH:

1. **Alkalinity is conservative.** However, instances are observed in the Snake River and Brownlee Reservoir where this is not the case.

    - Precipitation of calcium carbonate has been observed in the Snake River (e.g., white calcium carbonate deposits on the rocks). Referred to as marl, these deposits form when aqueous carbon dioxide is in equilibrium with the atmosphere and carbon dioxide is removed due to photosynthesis (Wetzel 2001). This results in a temporary excess of bicarbonate, which reacts with calcium.

    - There is the potential for carbonate release from anoxic and anaerobic sediments.

    - Alkalinity can decrease during photosynthesis with an uptake of ammonia, increase during respiration with the release of ammonia, or increase during photosynthesis with an uptake of nitrate (Stumm and Morgan 1995).

2. **Calcium and magnesium carbonate do not contribute to alkalinity.** Again, observations in the Snake River indicate this is not the case.

    - Calcium levels are relatively high in the Snake River.

    - Precipitated marl is commonly observed on substrate.

3. **Acidity is only due to carbonic acid concentration.** In the Snake River and most natural waters, organic and inorganic ions can contribute to acidity, including ammonium, HPO_4, and organic ligands.

In addition to the above assumptions, IPC would need to develop boundary conditions to model pH using the CE-QUAL-W2 model. These would include alkalinity, total dissolved solids (TDS), and TIC. These constituents were not routinely monitored during the years simulated with the CE-QUAL-W2 model. Therefore, the development of boundary conditions to model pH using the Brownlee Reservoir applications of the CE-QUAL-W2 model would be difficult.

More importantly, how these boundary conditions change with nutrient and algae reductions after the implementation of the SR–HC TMDL would require further assumptions. For example, to develop necessary boundary conditions for TIC, the alkalinity and pH would have to be assumed. The TIC and alkalinity would then be used in the model to predict pH.

As an alternative to pH simulation using the Brownlee Reservoir CE-QUAL-W2 model application, pH was simulated using the CE-QUAL-W2 model setup as an open system (i.e., a batch reactor). This batch reactor (single cell) application only requires initial conditions. Diel data collected in the Snake River (RM 345.6) upstream from Brownlee Reservoir indicated chlorophyll *a* concentrations in mid-July 2002 ranged from approximately 30 to 60 µg/L and pH ranged from approximately 7.9 to 8.3 SUs. To simulate this general range of algae, initial algal biomass conditions were set at 4 mg/L, which corresponds to 60 µg/L of chlorophyll *a* (assuming 1 mg/L algae equals 15 µg/L of chlorophyll *a*). Other initial conditions were estimated using data collected upstream of Brownlee Reservoir on the Snake River in summer

2002. Brownlee Reservoir model meteorological data were used to represent solar inputs and temperatures. There were no inflows or outflows in this application.

6.5.3.1.2.1. pH Simulations with Varying Algal Levels

Simulated maximum pH varied with differing initial conditions for algal biomass, resulting in maximum pH values occurring when algal levels were highest (Table 6.5-2). However, there is only a slight change in average pH levels.

Table 6.5-2
pH values in SUs resulting from CE-QUAL-W2 simulations of varying algal biomass initial conditions

	Initial Condition			Algal Growth Rate	pH	
	Algal Biomass	Alkalinity	TIC		Average	Maximum
Simulation 1	4.00	100.00	23.40	4.00	8.64	8.85
Simulation 2	2.00	100.00	23.40	4.00	8.64	8.74
Simulation 3	1.00	100.00	23.40	4.00	8.66	8.74

Simulation results showed daily algal biomass fluctuations with maximums occurring in response to maximum photosynthesis rates (Figure 6.5-6). Corresponding pH and TIC fluctuations also occurred (figures 6.5-7 and 6.5-8). For these simulations, TIC was set to produce levels that remained relatively constant over the period (i.e., at equilibrium with algae, alkalinity, and the atmosphere). Consistent with levels observed in the Snake River, alkalinity was set at 100 g/m^3 as calcium carbonate (USGS 2003).

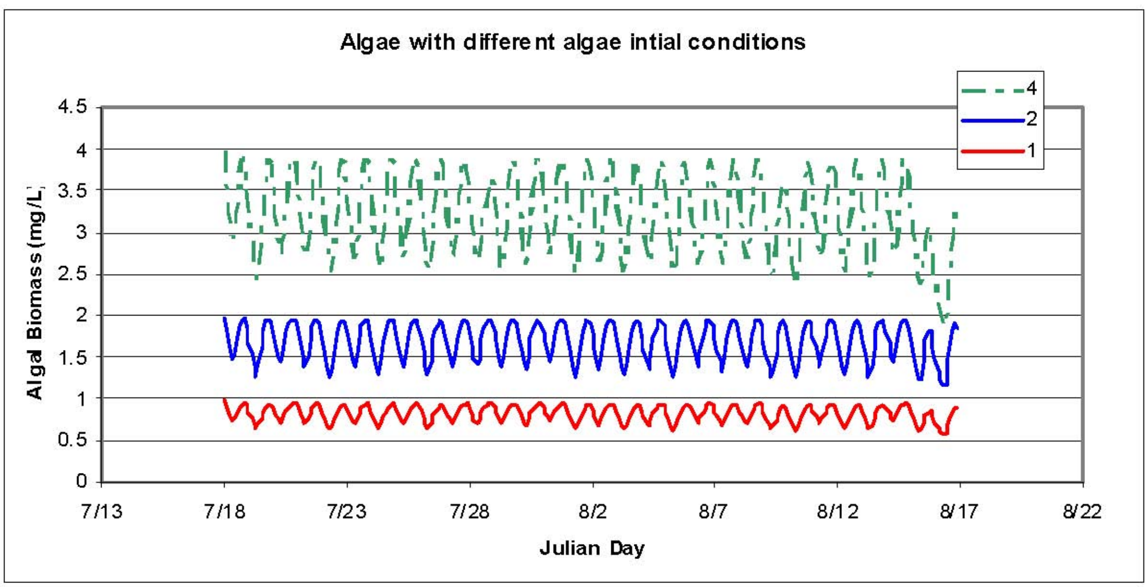


Figure 6.5-6
Algal biomass in mg/L with algal biomass initial conditions varying from 1 to 4 mg/L (i.e., approximately 15–60 µg/L of chlorophyll *a*)

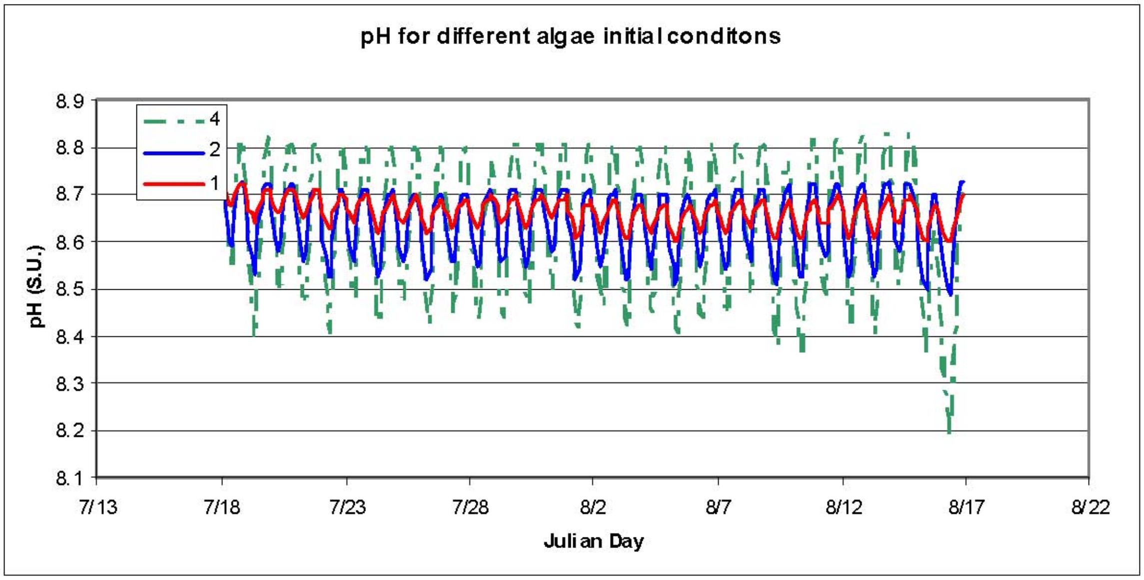


Figure 6.5-7
pH values in SUs with algal biomass initial conditions varying from 1 to 4 mg/L (i.e., approximately 15–60 µg/L of chlorophyll *a*)

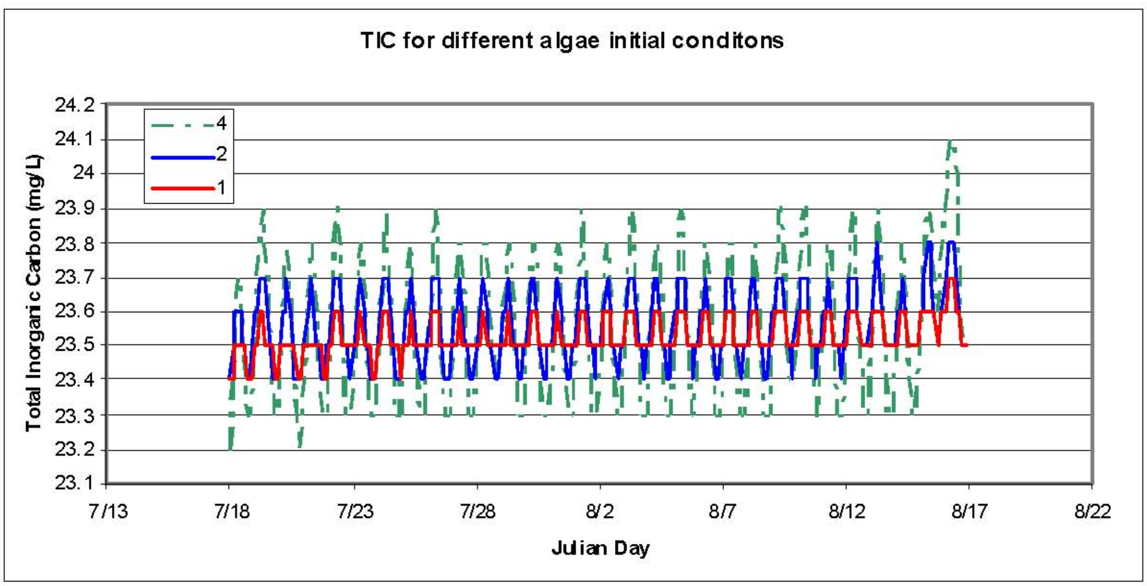


Figure 6.5-8
TIC in mg/L with algal biomass initial conditions varying from 1 to 4 mg/L (i.e., approximately 15–60 µg/L of chlorophyll *a*)

6.5.3.1.2.2. pH Simulations with Varying Algal Growth Rates

The CE-QUAL-W2 model simulation results (Table 6.5-3 and figures 6.5-9 and 6.5-10) showed the related daily range of algae as chlorophyll *a* and pH for mid-July with 2 growth rates (4 and 2 per day, respectively). The algal growth rate was set at 4 per day to simulate the relatively large daily fluctuation (Figure 6.5-9) representative of those observed in the measured data.

This growth rate was double the rate used in the 1995 Brownlee Reservoir optimized model application (Harrison et al. 1999).

Table 6.5-3
pH values in SUs resulting from CE-QUAL-W2 simulations of varying algal growth-rate initial conditions

	Initial Condition			Algal Growth Rate	pH	
	Algal Biomass	Alkalinity	TIC		Average	Maximum
Simulation 1	4.00	100.00	23.40	4.00	8.64	8.85
Simulation 2	4.00	100.00	23.40	2.00	8.61	8.74

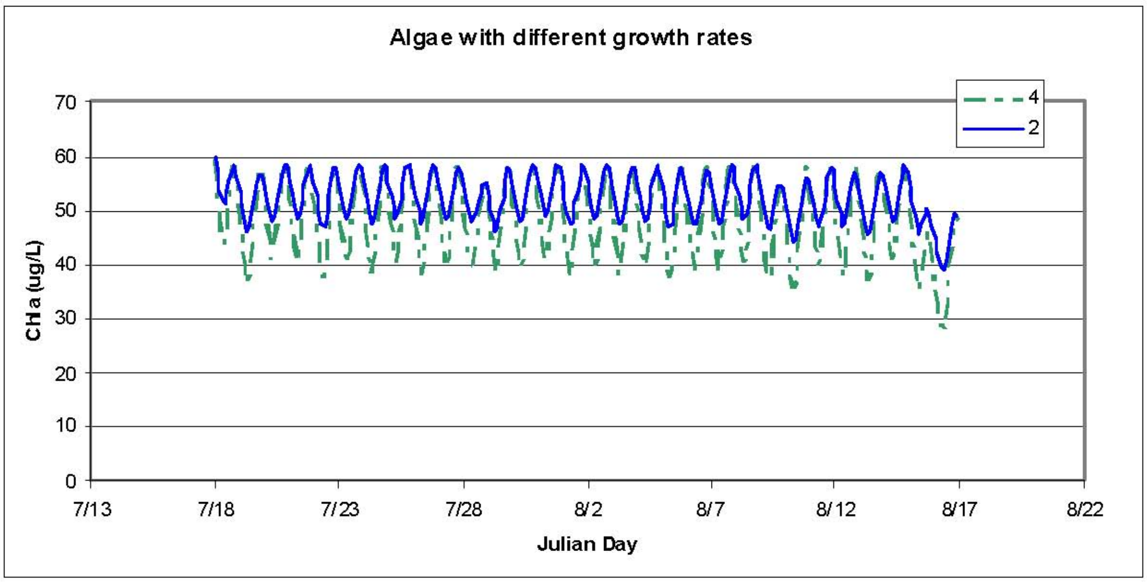


Figure 6.5-9
Algal biomass as measured by chlorophyll *a* (Chl *a*) in µg/L with algal growth rate initial conditions of 2 and 4 per day

These results showed that algal growth rates also affected pH levels. In the model, algal biomass was multiplied by the growth rate. Thus, a higher algal biomass can drive a higher rate of photosynthesis and higher pH values if other factors are not limiting (e.g., light and nutrients) (Table 6.5-3). Higher algal biomass produced higher pH values. This was consistent with the mass balance model results (Figure 6.5-5).

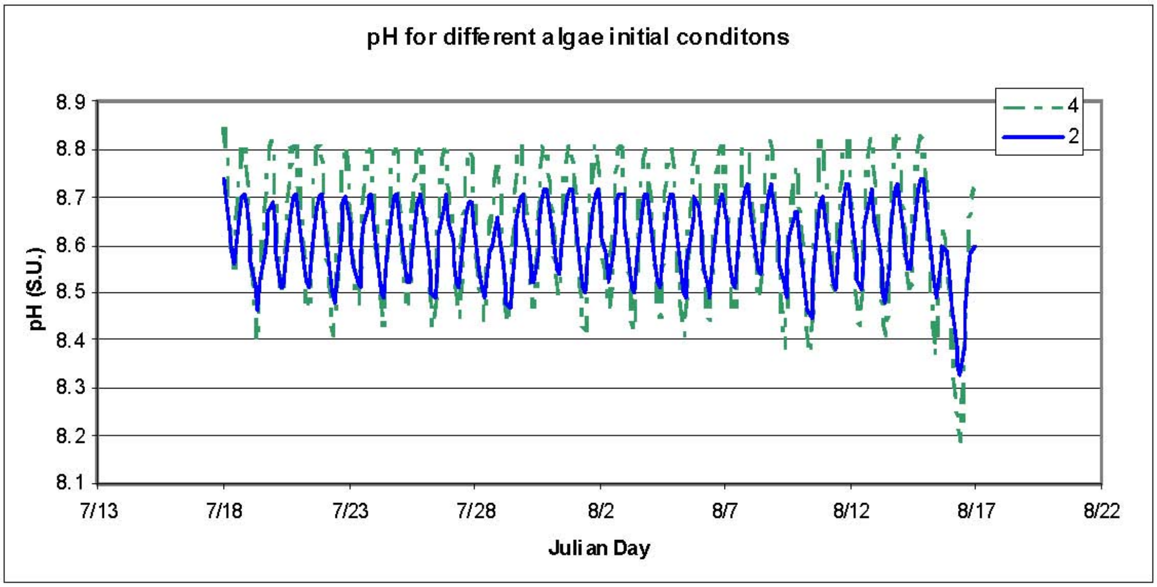


Figure 6.5-10
pH values in SUs with algal growth rate initial conditions of 2 and 4 per day

6.5.3.1.2.3. pH Simulations with Varying Alkalinity

The effects of alkalinity on pH values were modeled while keeping algae conditions constant (Table 6.5-4). The higher alkalinity produced slightly lower maximum pH values (figures 6.5-11 and 6.5-12). However, average pH was higher with the higher alkalinity because minimum pH values were higher. The mass balance model (Figure 6.5-5) showed higher, steady-state pH values when alkalinity was higher, as would be expected. Changes in alkalinity can occur with nutrient assimilation by algae, a process not included in the CE-QUAL-W2 model (Cole and Wells 2002).

Table 6.5-4
pH values in SUs resulting from CE-QUAL-W2 simulations of varying alkalinity initial conditions

	Initial Condition			Algal Growth Rate	pH	
	Algal Biomass	Alkalinity	TIC		Average	Maximum
Simulation 1	4.00	10.00	2.20	4.00	7.93	9.01
Simulation 2	4.00	20.00	4.60	4.00	8.09	8.90
Simulation 3	4.00	30.00	7.20	4.00	8.18	8.84
Simulation 4	4.00	40.00	9.20	4.00	8.30	8.86
Simulation 5	4.00	100.00	23.20	4.00	8.60	8.85

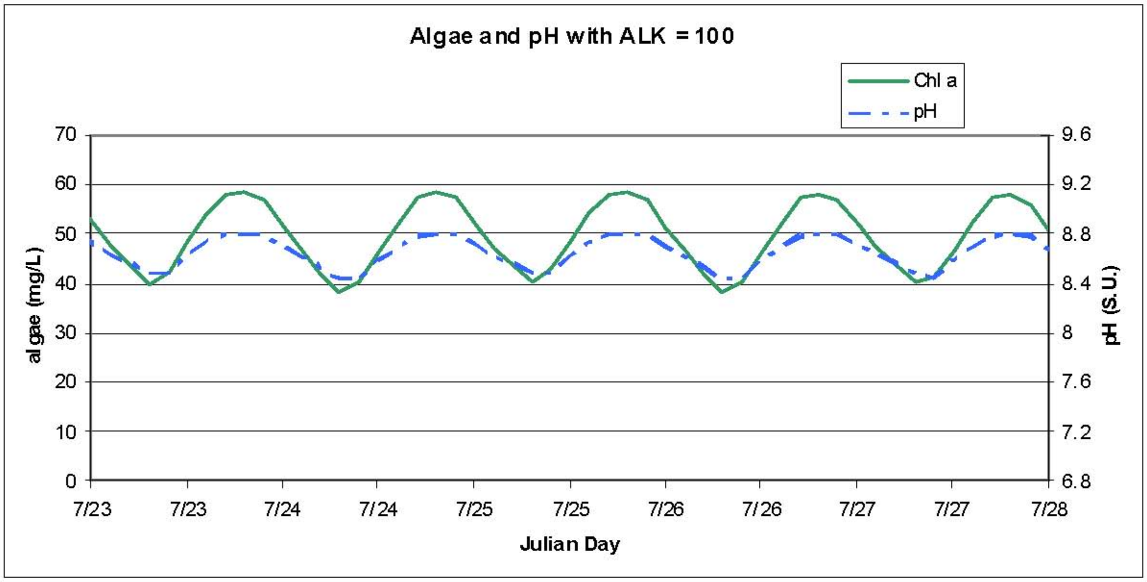


Figure 6.5-11
Algae in mg/L and pH in SUs with alkalinity equal to 100, algal biomass initial conditions of 4 mg/L, and an algal growth rate of 4 per day

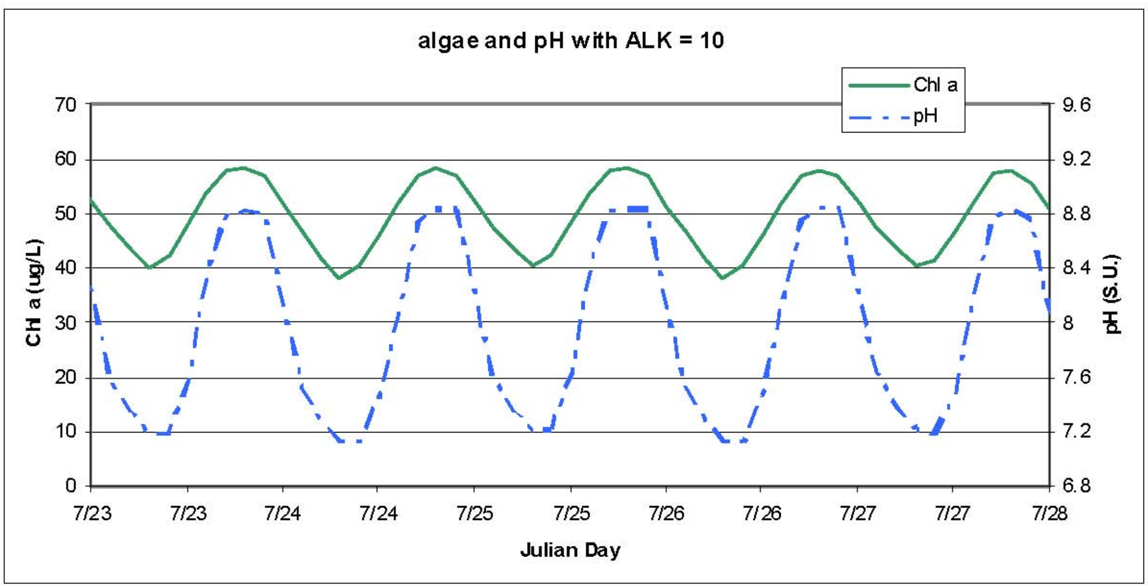


Figure 6.5-12
Chlorophyll *a* (Chl a) in µg/L and pH in SUs with an alkalinity equal to 100 and algal biomass initial conditions of 4 mg/L and an algal growth rate of 4 per day

6.5.3.2. pH Reasonable Assurance

IPC was not issued a pH allocation as part of the SR–HC TMDL (IDEQ and ODEQ 2004). Rather, nuisance algal targets and TP allocations to support the targets were expected to provide reasonable assurance that the few pH exceedances would be ameliorated. The SR–HC TMDL presented an analysis that developed a TP target of 0.07 mg/L for the stated purpose of attaining the mean growing season chlorophyll *a* target of 14 µg/L and a nuisance threshold of 30 µg/L, not to be exceeded more than 25% of the time for the Snake River and the HCC. When reduced primary production is realized, following full implementation of the SR–HC TMDL and attainment of both TP and chlorophyll *a* targets, the potential for pH values above targets will decrease.

This SR–HC TMDL conclusion was supported by IPC’s modeling, which demonstrated lower maximum pH values are expected as algal levels and growth rates are reduced. As stated previously, algal growth can induce changes in alkalinity through the removal of nutrient ions (i.e., the assimilation of nitrate and hydrogen phosphate ions). With lower rates of photosynthesis through the implementation of the nutrient TMDL, lower nutrient-removal rates and a lower pH would be anticipated. While model boundary conditions are variable and future conditions difficult to predict, it is apparent that management actions designed to reduce algae production in the Snake River upstream of Brownlee Reservoir can have a positive influence on pH values, lowering maximum values and the potential for an exceedance of the pH targets.

6.6. Toxics

The SR–HC TMDL identified mercury as a toxic of concern (IDEQ and ODEQ 2004). Oregon has listed the Snake River from the Oregon and Idaho border through the HCC downstream to the Oregon and Washington border as impaired for mercury (Table 5.1-1). Similarly, Idaho has listed Brownlee and Hells Canyon reservoirs as impaired for mercury (Table 5.1-2). The OHA (OHA 2013) has issued a fish-consumption advisory for Brownlee Reservoir, and the IDHW (IDHW 2013) has issued fish-consumption advisories for Brownlee and Hells Canyon reservoirs. The SR–HC TMDL also identified DDT (total-DDT [t-DDT]), DDD, DDE, 2 environmental metabolites of t-DDT, and dieldrin as toxics of concern (IDEQ and ODEQ 2004). Similar to mercury, pesticides have a diffuse and widespread legacy. Both t-DDT and dieldrin have been banned for use (t-DDT in 1973 and dieldrin in 1987). More detail on metals and pesticides in fish tissue and bed sediments of the HCC reservoirs is available in Technical Report E.2.2-2 of the *New License Application: Hells Canyon Hydroelectric Complex*.

Of the toxics of concern identified in the SR–HC TMDL and through subsequent study, mercury remains a primary concern. The SR–HC TMDL identified the primary sources of the total mercury in Brownlee Reservoir as legacy mining and natural loading, both associated with geological deposits within the Owyhee and Weiser river watersheds, and air deposition (IDEQ and ODEQ 2004). The SR–HC TMDL determined a mercury TMDL for this stretch of the Snake River is needed, which will be the basis for load and waste load allocations for nonpoint and point sources, respectively, contributing to mercury in these waters (SR–HC TMDL at page 255). However, because of insufficient data, no action has been taken on that TMDL at this time.

The cycling of mercury among its many pools and forms in aquatic environments is complex. Mercury in the aquatic environment can be converted by bacteria to a more toxic form called methylmercury. Inorganic mercury and toxic bioaccumulative methylmercury compounds are partitioned among the sediment, water, and biota pools in both organic and inorganic and dissolved and particulate forms. The majority of inorganic mercury is typically stored in sediments (Meili 1997). Concentrations of methylmercury and proportions of methylmercury to inorganic mercury depend on the balance of methylation, demethylation, and chemical stabilization in the system. Methylmercury is formed by the methylation of inorganic mercury in the presence of organic matter. Methylation is thought to be a microbial process highly dependent on sulfate-reducing and potentially methanogenic bacteria in anoxic conditions, although it can also occur in oxic conditions (Miskimmin et al. 1992). Demethylation, which is also controlled directly by microbial activity or abiotically by sunlight, is highest in oxic photic zones (Meili 1997).

Organic matter concentrations and cycling exert a strong control on the transport and transformations of mercury in aquatic environments. Concentrations of methylmercury and total mercury typically increase with the concentration of DOC (Driscoll et al. 1994). Other important parameters influencing the cycle include concentrations and redox states of iron, manganese, chloride, and sulfur compounds.

6.6.1. Toxics Standards and SR–HC TMDL Targets

Oregon and Idaho have promulgated narrative standards and numeric criteria for toxics. Oregon's narrative standards prohibit the introduction of potentially harmful toxic substances above natural background levels (OAR 340-041-0033(2)) and the creation of tastes, odors, or toxic conditions deleterious to fish or other aquatic life or that affect the potability of drinking water or the palatability of fish or shellfish (OAR 340-041-0007(10)). Oregon water-quality standards (OAR 340-041-002(67)) define a toxic substance as follows:

> Those pollutants or combinations of pollutants, including disease-causing agents, that after introduction to waters of the state and upon exposure, ingestion, inhalation, or assimilation either directly from the environment or indirectly by ingestion through the food chains will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations in any organism or its offspring.

Idaho narrative standards similarly prohibit toxic substances in concentrations that impair beneficial uses (IDAPA 58.01.02.200.02). Idaho water-quality standards (IDAPA 58.01.02.010.102) similarly define a toxic substance as the following:

> Any substance, material or disease-causing agent, or a combination thereof, which after discharge to waters of the State and upon exposure, ingestion, inhalation or assimilation into any organism (including humans), either directly from the environment or indirectly by ingestion through food chains, will cause death, disease, behavioral abnormalities, malignancy, genetic mutation, physiological abnormalities (including malfunctions in reproduction) or physical deformations in affected organisms or their offspring. Toxic substances include, but are not limited to, the one hundred twenty-six (126) priority pollutants identified by EPA pursuant to Section 307(a) of the federal Clean Water Act.

The toxics criteria for human health are based in part on the fish-consumption rate. In 2004, Oregon adopted human-health criteria based on the EPA's CWA § 304(a) guidance values.

These criteria were calculated using EPA's default fish-consumption rate of 17.5 g/day, a rate that represents the 90th percentile of consumers and nonconsumers based on a national U.S. Department of Agriculture (USDA) consumption study (1994–1996 and 1998 *Continuing Survey of Food Intakes by Individuals*).

In June 2010, the EPA disapproved Oregon's 2004 human-health criteria. Oregon undertook a negotiated rulemaking and promulgated new rules and, in 2011, the EPA subsequently approved Oregon's revised human-health criteria for toxics based on the fish-consumption rate of 175 g/day.

In 2006, Idaho adopted the EPA's recommended consumption rate of 17.5 g fish/day of freshwater or estuarine fish. The EPA disapproved this fish consumption rate in 2012. The EPA's disapproval of Idaho's human-health toxics criteria includes Idaho's criteria for toxics of concern in the Hells Canyon reach of the Snake River, DDT, DDE, DDD, and dieldrin. The EPA's disapproval does not apply to Idaho's criterion for methylmercury because that criterion was not included in the criteria submitted by Idaho in 2006 and disapproved by the EPA in 2012. However, because Idaho's standard for methylmercury is based on the EPA's recommended fish-consumption rate of 17.5 g/day, a change to the fish consumption rate will ultimately impact Idaho's methylmercury standard. This accounts for the current different methylmercury fish-tissue criteria of Idaho's 0.3 mg/kg to Oregon's 0.04 mg/kg, a significantly more stringent standard.

Oregon's human-health criteria for toxic pollutants are established in OAR 340-041-0033 Table 40, and criteria for aquatic life are provided in tables 20, 33A, and 33B. Table 6.6-1 lists Oregon's numeric criteria for mercury, methylmercury, t-DDT, DDD, DDE, and dieldrin for the protection of human health and aquatic life. Table 6.6-2 similarly lists Idaho's numeric criteria (IDAPA 58.01.02.210).

Table 6.6-1
Oregon human-health and aquatic-life criteria applicable to the Snake River for mercury, methylmercury, t-DDT, DDD, DDE, and dieldrin in mg/kg of fish-tissue concentration and µg/L water-column concentration. Human-health criteria were taken from OAR 340-041-0033 Table 40 and aquatic-life criteria from tables 20, 33A, and 33B.

	Human Health		Aquatic Life	
Pollutant	**Water + Organism**	**Organism Only**	**Acute**	**Chronic**
Mercury	–	–	2.40 µg/L	0.012 µg/L
Methylmercury	–	0.0400000 mg/kg	–	–
t-DDT	0.0000220 µg/L	0.0000220 µg/L	1.10 µg/L	0.001 µg/L
DDD	0.0000310 µg/L	0.0000310 µg/L	–	–
DDE	0.0000220 µg/L	0.0000220 µg/L	–	–
Dieldrin	0.0000053 µg/L	0.0000054 µg/L	0.24 µg/L	0.056 µg/L

Table 6.6-2
Idaho human-health and aquatic-life criteria applicable to the Snake River for mercury, methylmercury, t-DDT, DDD, DDE, and dieldrin in mg/kg of fish-tissue concentration and µg/L water-column concentration. Criteria were taken from IDAPA 58.01.02.210.

	Human Health		Aquatic Life	
Pollutant	**Water + Organism**	**Organism Only**	**Acute**	**Chronic**
Mercury	–	–	2.1 µg/L	0.0120 µg/L
Methylmercury	–	0.300000 mg/kg	–	–
t-DDT	0.000220 µg/L	0.000220 µg/L	1.1 µg/L	0.0010 µg/L
DDD	0.000310 µg/L	0.000310 µg/L	–	–
DDE	0.000220 µg/L	0.000220 µg/L	–	–
Dieldrin	0.000052 µg/L	0.000054 µg/L	2.5 µg/L	0.0019 µg/L

Some of the SR–HC TMDL toxic substance targets vary from Oregon's and Idaho's numeric criteria. Total mercury targets were similar (not to exceed 0.012-µg/L water-column concentration), while methylmercury targets were different (not to exceed 0.35 mg/kg in fish tissue) (IDEQ and ODEQ 2004). Only water-column concentrations were established for pesticides: not to exceed 0.000024 µg/L t-DDT, 0.00083 µg/L DDD, 0.00059 µg/L DDE, and 0.00007 µg/L dieldrin.

6.6.2. Conditions Relative to Toxics

Most of the available information on toxic-substance concentrations in the HCC, until very recently, focused on fish tissue and bed sediment. Currently, there are no numeric criteria applicable to bed sediments. IPC will present information on toxic substance concentrations in bed sediments only to frame the natural loading and legacy mining issues discussed in the SR–HC TMDL (IDEQ and ODEQ 2004) and by Brandt and Bridges (2007).

Several researchers reported concentrations of inorganic trace elements other than mercury and organic compounds other than t-DDT and dieldrin. Generally, none of the trace elements or organic concentrations exceeded criteria (Clark and Maret 1998; Essig and Kosterman 2008; Harrison et al. 2012[31]; Fosness et al. 2013[32]). An assessment of existing data on mercury concentrations in fish tissue, water column, and bed sediments of the HCC reservoirs is available in Harris and Beals (2013)[33].

Additionally, heavy metal and organochlorine pesticide contamination was studied in bald eagles (*Haliaeetus leucocephalus*) nesting in the HCC. Researchers reported that all adult feather samples collected in the HCC had levels of mercury that exceeded the accepted level of concern

[31] Harrison et al. (2012) is provided with this application as Exhibit 6.6-1.

[32] Fosness et al. (2013) is provided with this application as Exhibit 6.6-2.

[33] Harris and Beals (2013) is provided with this application at Exhibit 6.6-3.

(Bechard et al. 2005). Nevertheless, the levels of mercury contamination reported did not appear lethal, and all bald eagles sampled were breeding successfully. All nestling blood samples collected in the HCC contained measurable levels of t-DDT and dieldrin. Again, the results did not indicate that organochlorine pesticide contamination occurred at levels sufficiently high to cause reproductive failures or other toxic effects in bald eagles in the HCC.

6.6.2.1. Fish Tissue

6.6.2.1.1. Mercury and Methylmercury

Many researchers have reported mercury and methylmercury concentrations in fish tissue collected in the HCC as well as throughout the Snake River watershed (Clark and Maret 1998; Adams 2008; Essig and Kosterman 2008; and Essig 2010). While most of these studies reported samples exceeding criteria, there are limitations to making meaningful conclusions due to insufficient sample size or composited samples, mixtures of whole body and muscle tissue, fish species across trophic levels, and varying fish sizes (Essig and Kosterman 2008; Essig 2010; Harris and Beals 2013).

Clark and Maret (1998) reported that mercury concentrations in fish collected in Brownlee Reservoir at the Burnt River ranged from an average of 0.273 mg/kg wet weight in white crappie fillets to an average of 0.325 mg/kg wet weight in channel catfish fillets. Common carp (*Cyprinus carpio*) average liver concentrations (0.315 mg/kg) also exceeded the Oregon and Idaho criterion but are not usually consumed. Stone (2006a) reported a mean Brownlee Reservoir-wide concentration of methylmercury in smallmouth bass fillets (0.633 mg/kg). He also reported a high degree of variability among the sampling sites. Essig and Kosterman (2008) reported methylmercury contamination in piscivorous fish from both Brownlee and Hells Canyon reservoirs. Brownlee Reservoir black crappie and catfish had average fish-tissue concentrations of 0.317 mg/kg and 0.388 mg/kg, respectively. Concentrations reported for fish in Hells Canyon Reservoir were 0.561 mg/kg in crappie, 0.556 mg/kg in catfish, and 0.471 mg/kg in smallmouth bass.

In spring 2013, IPC collected fish-tissue samples for methylmercury from 30 smallmouth bass in each of the HCC reservoirs, Brownlee, Oxbow, and Hells Canyon and from 30 smallmouth bass from the Snake River below HCD. Smallmouth bass were collected across a range of sizes representing 6 size groups (<100 millimeters [mm], 101–150 mm, 151–200 mm, 201–250 mm, 251–300 mm, and 301–350 mm). The methylmercury levels in smallmouth bass muscle tissue generally increased with size and ranged from 0.026 µg/g in Oxbow Reservoir to 0.75 µg/g in Hells Canyon Reservoir (Figure 6.6-1). Of the smallmouth bass sampled, 8 met Oregon's human-health criteria for methylmercury, and 112 exceeded Oregon's criteria. The 8 that met Oregon's methylmercury criteria were from Oxbow Reservoir and the Snake River below HCD and were from the <100 mm size group. Eighty-two of the smallmouth bass sampled met Idaho's methylmercury criteria, while 38 smallmouth bass exceeded Idaho's criteria. All of the smallmouth bass in the size groups less than 200 mm were below the Idaho criteria. The methylmercury levels found in the bass muscle tissue are an issue because the data indicate an exceedance of both Idaho and Oregon water-quality criteria for methylmercury in fish tissue.

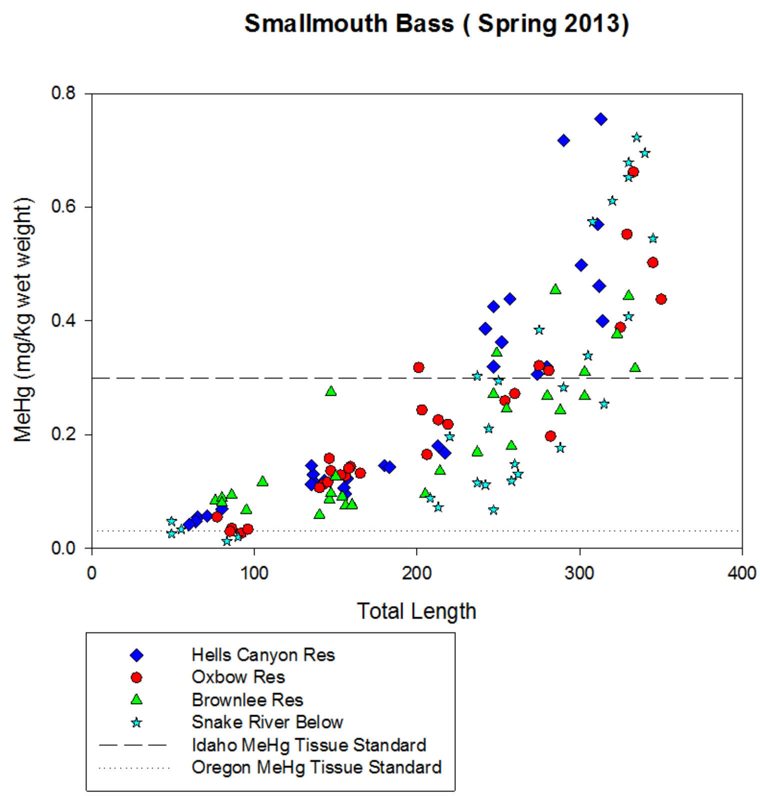


Figure 6.6-1
Smallmouth bass methylmercury tissue concentrations, spring 2013

As a follow-up to the spring 2013 analysis, IPC collected 24 individual smallmouth bass in fall 2013 between 250 and 300 mm at each of the following locations: below Swan Falls Dam, Snake River below the confluence of the Boise River, Snake River at the inflow to Brownlee Reservoir, the upper end of Brownlee Reservoir, the forebay of Brownlee Dam, the forebay of Oxbow Dam, the forebay of HCD, the river below HCD and the Snake River in the vicinity of Pittsburg Landing, and the Snake River in the vicinity above the confluence of the Salmon River. The purpose of these data were to better understand the distribution and trend of methylmercury within fish tissue in the Snake River above, within, and below the HCC reservoirs. As depicted in Figure 6.6-2, levels of methylmercury generally increase in fish tissue downstream through the HCC reservoirs, with some of the higher levels observed within Hells Canyon Reservoir. Generally, levels decline downstream of HCD, with some of the higher levels immediately below HCD.

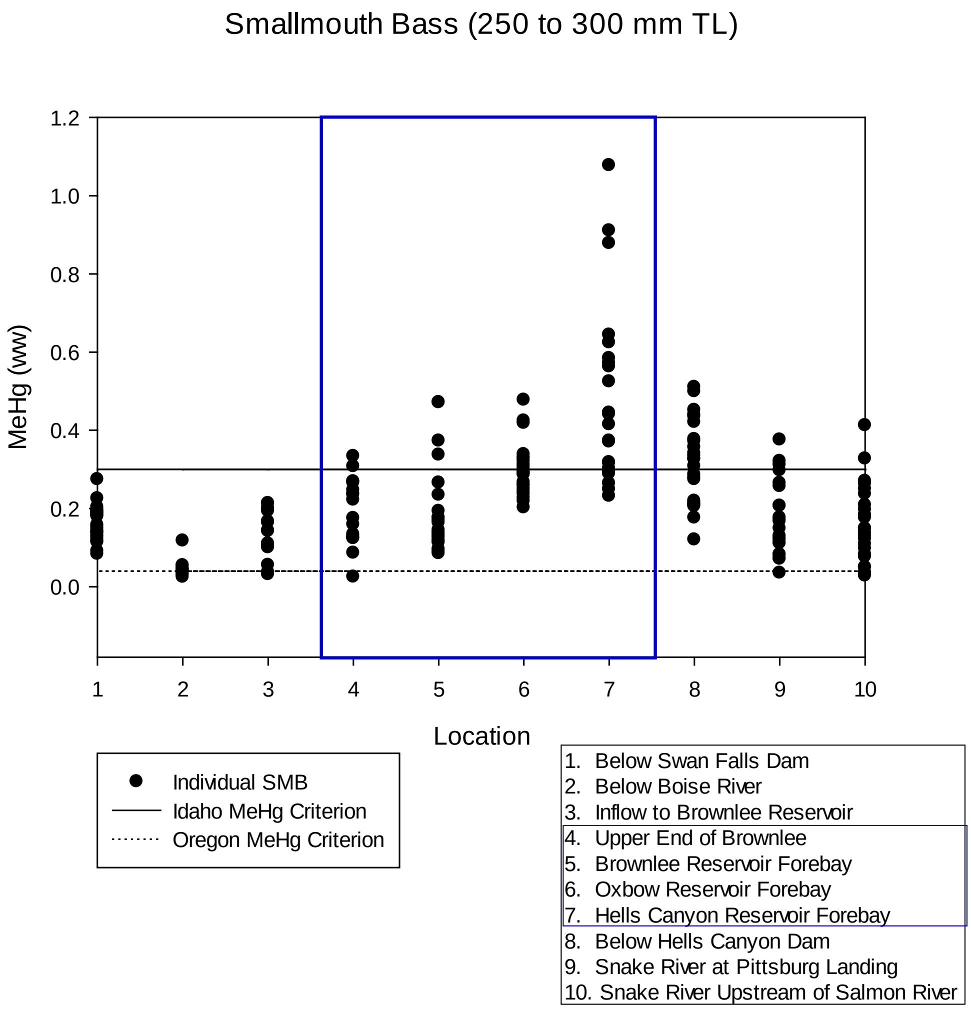


Figure 6.6.-2
Longitudinal distribution of methylmercury (mg/kg; wet weight) levels of tissue samples from individual smallmouth bass between 250 and 300 mm total length (TL) from Snake River locations ranging from below Swan Falls Dam (RM 458) to upstream of the confluence of the Salmon River (RM 188).

Three different life stages of SRFC salmon were analyzed for levels of methylmercury. These include the egg, fry, and adult life stages. A sample size of 30 fry were collected from 3 entrapment pools in the Snake River at RM 190.3 (n = 12), 199.3 (n = 14), and 227.3 (n = 4). Fry ranged in size from 42 to 60 mm TL. Because of their small size, whole fish rather than just muscle tissue was analyzed. As expected, methylmercury levels in these fish were very low, ranging from 0.0024 to 0.0073 mg/kg of methylmercury (wet weight; Figure 6.6-3. Adults and eggs were collected from spawned broodstock at Lyons Ferry Hatchery in fall 2013. Tissue was collected from 30 females, and a sample of eggs was collected from each female. Methylmercury levels in the eggs were low, ranging from 0.0005 to 0.0072 mg/kg methylmercury (wet weight; Figure 3). Adult SRFC salmon were all below the Idaho human-health fish tissue criterion but were more variable, ranging from 0.029 to 0.21 mg/kg of methylmercury with a median value of 0.087 mg/kg wet weight (Figure 6.6-3).

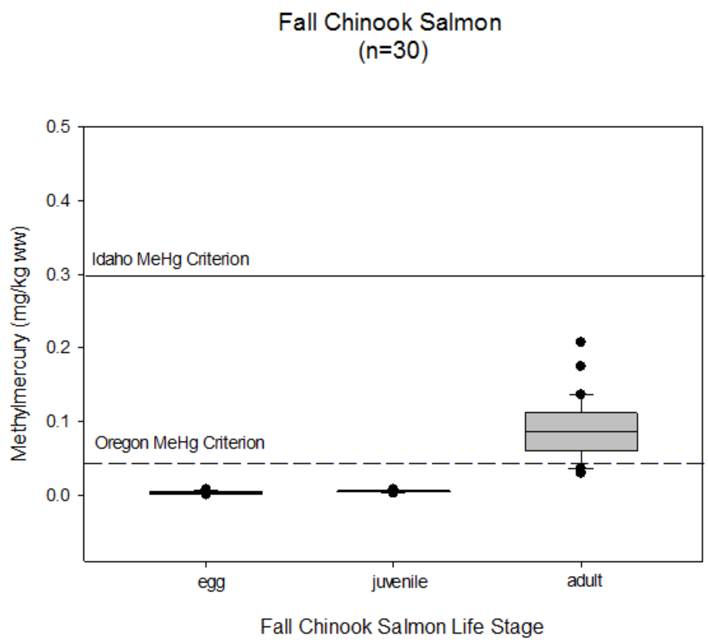


Figure 6.6.-3
Box plots of methylmercury (mg/kg wet weight) showing the median, 10th, 25th, 75th, and 90th percentile levels (horizontal lines) with outlier points for eggs, fry, and adult SRFC salmon relative to the Idaho human-health fish tissue criterion.

In summer 2014, a bull trout mortality event occurred in the vicinity of and within the ODFW spring Chinook salmon trap on the mainstem Imnaha River (near Gumboot Creek). A total of 29 individuals were collected during this event ranging in size from 375 mm to 730 mm TL. This allowed an opportunity to obtain muscle tissue samples for methylmercury analysis. Generally, methylmercury levels increase with size, with some of the larger individuals exceeding the Idaho methylmercury human-health tissue criterion (Figure 6.6-4). All of the bull trout sampled exceeded the Oregon human health fish-tissue criteria. Levels of methylmercury ranged from 0.076 to 0.383 mg/kg methylmercury (wet weight).

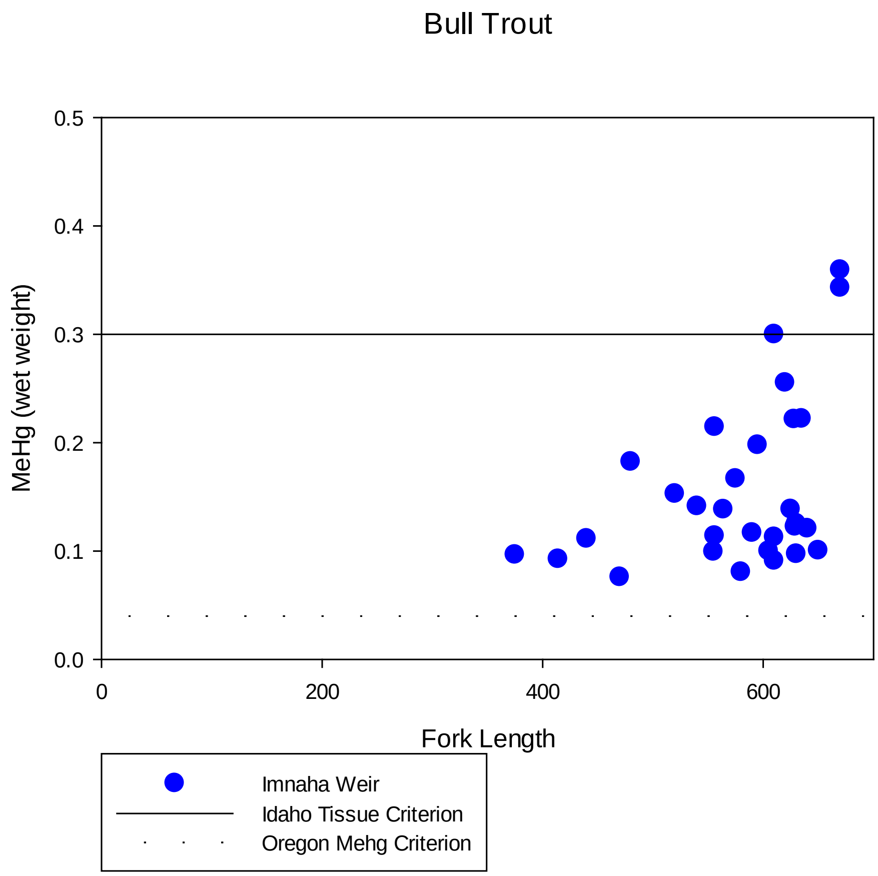


Figure 6.6.-4
Scatter plot of methylmercury levels (mg/kg, wet weight) of individual bull trout collected in the vicinity of the ODFW spring Chinook salmon trap (near the confluence of Gumboot Creek) relative to the Idaho human-health tissue criterion.

In 2014, IPC collected tissue samples using dermal plugs from the dorsal musculature of white sturgeon from areas between Swan Falls Dam (RM 458 to Noble Island [RM 445]; n = 25), the upper portion of Brownlee Reservoir (n = 4) and below HCD (n = 29), within the vicinity of Pittsburg Landing. In addition, IPC had collected muscle tissue samples from incidental mortalities of white sturgeon found in the river below CJ Strike Dam (n = 7) and below Swan Falls Dam (n = 2) during 2012 and 2013. Most white sturgeon sampled exceeded the Idaho human health fish tissue criterion; all white sturgeon exceeded the Oregon human health fish tissue criterion. Generally, methylmercury increases with fish size among areas above and below HCD, with some of the larger individuals having relatively high levels (Figure 6.6-5). Methylmercury levels generally are greater below HCD based on fish size (Figure 6.6-5). However, age-at-length relationships for white sturgeon above and below the HCC are different. Generally fish of the same age are larger above the HCC than below the HCC. Growth models for each of the two areas (Bates et al. 2014) were used to assign ages to each of the sampled sturgeon. Sturgeon of similar ages from both areas were similar in their levels of methylmercury (Figure 6.6-6). This suggests that Snake River white sturgeon have elevated levels of methylmercury and may bioaccumulate at similar levels based on age regardless of location.

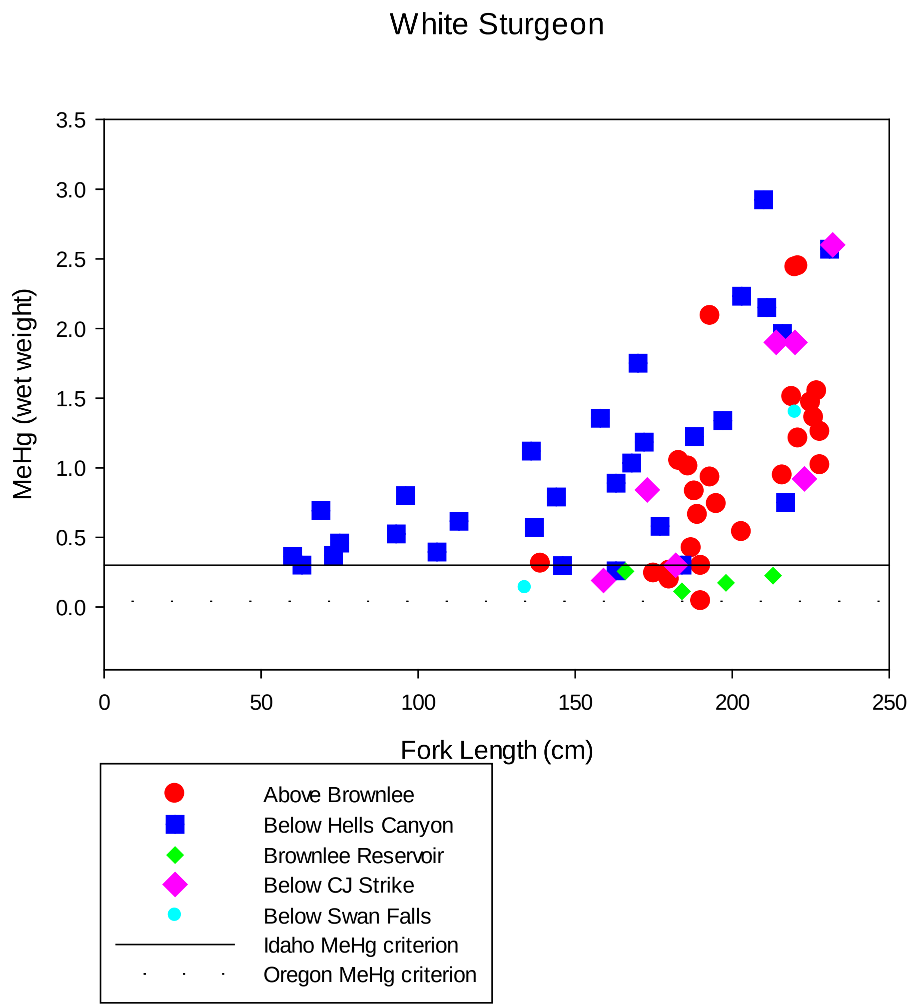


Figure 6.6-5
Scatter plot of methylmercury levels (mg/kg, wet weight) relative to the fork length of individual white sturgeon from dermal muscle plugs in the dorsal musculature above Brownlee Dam, Brownlee Reservoir, and below Hells Canyon dam upstream of Pittsburg Landing. Additional samples are included in the plot that were collected from incidental observed mortalities in 2012 and 2013 below C. J. Strike Dam (n = 7, purple diamonds) and below Swan Falls Dam (n = 2, light-blue circles) relative to the Idaho human-health tissue criterion.

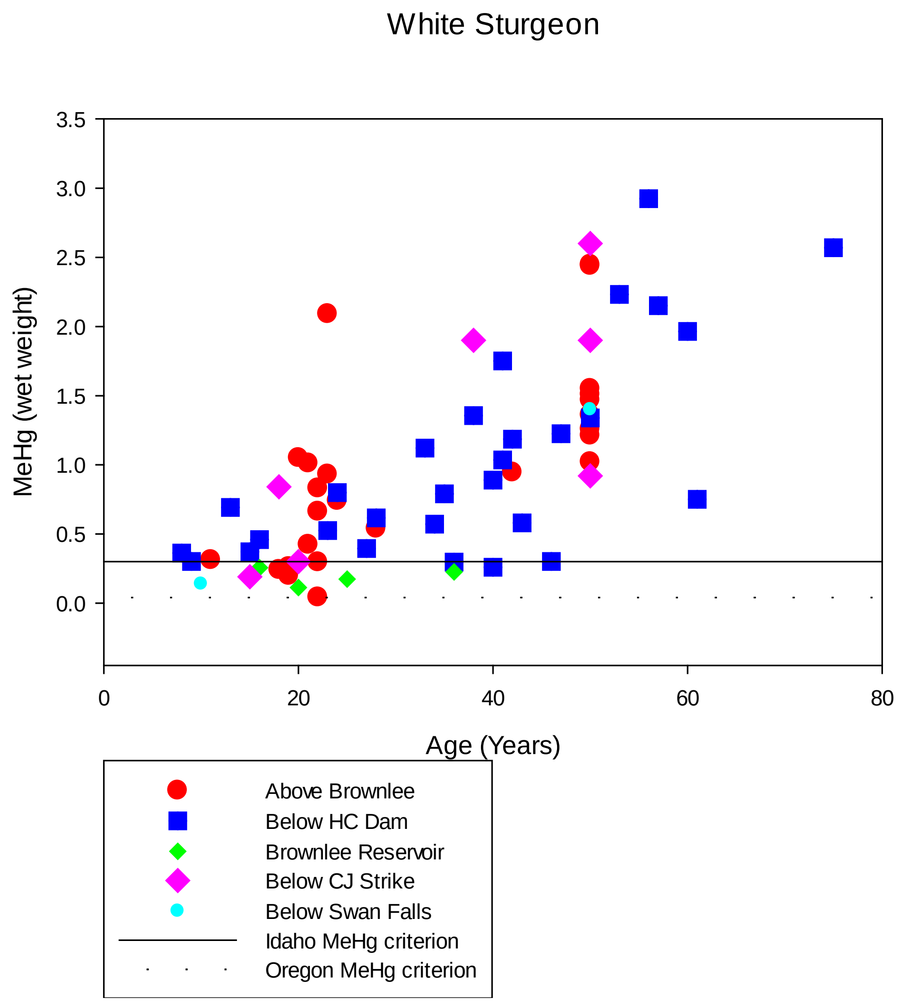


Figure 6.6-6
Scatter plot of methylmercury levels (mg/kg, wet weight) relative to the estimated age (years) of individual white sturgeon from dermal muscle plugs in the dorsal musculature above Brownlee Dam, Brownlee Reservoir, and below Hells Canyon dam upstream of Pittsburg Landing. Additional samples are included in the plot that were collected from incidental observed mortalities in 2012 and 2013 below C. J. Strike Dam (n = 7, purple diamonds) and below Swan Falls Dam (n = 2, light-blue circles) relative to the Idaho human health tissue criterion.

6.6.2.1.2. Pesticides and Organic Compounds

Clark and Maret (1998) also reported detectable concentrations of organochlorine compounds in sportfish fillets collected in Brownlee Reservoir. Concentrations of t-DDT and dieldrin exceeded a cancer-risk screening value of 10-6 as established by the EPA.

6.6.2.2. Water Column

In 2010 and 2011, IPC sampled the Brownlee Reservoir water column for 470+ toxics based on a list developed in collaboration with the FWS, IDEQ, ODEQ, and others (Harrison et al. 2012). This study sampled Brownlee Reservoir's hypolimnion and discharge for organic and inorganic toxics concentrations. The results from Brownlee Dam discharge samples, which represent water primarily drawn from the upper and middle levels of the reservoir (i.e., epilimnion and metalimnion), were compared with the results from samples collected in the lower depths of Brownlee Reservoir (i.e., hypolimnion). In general, concentrations of most of the parameters tested, including most inorganic toxics and all organic toxics, were lower in the hypolimnion compared to the discharge. However, this trend did not apply to select inorganic toxics, including chromium, ammonia, or mercury, where levels of chromium, ammonia, and mercury were higher in the hypolimnetic waters.

6.6.2.2.1. Mercury and Methylmercury

Many have sampled total mercury through the water column in Brownlee Reservoir. All reported maximum concentrations less than either chronic or acute aquatic-life criteria (Stone 2006b; Brandt and Bridges 2007; Harrison et al. 2012; and Fosness et al. 2013).

Harrison et al. (2012) reported the highest methylmercury concentration of 2.9 ng/L (0.0029 µg/L) in the hypolimnion of Brownlee Reservoir in fall 2011. Both Fosness et al. (2013) and Harrison et al. (2012) show higher concentrations near the bottom of the reservoir and in the hypolimnion, which is in contrast to a maximum methylmercury concentration of 0.1 ng/L (0.0001 µg/L) measured in the discharge from Brownlee Reservoir (Harrison et al. 2012). This contrast suggests methylmercury accumulates in the deeper waters of Brownlee Reservoir throughout the year. Harris and Beals (2013) reported the methylmercury concentration and the percent of mercury in the form of methylmercury in the hypolimnion were significantly elevated when compared to the mean and median values nationally.

Fosness et al. (2013) partitioned Brownlee Reservoir mercury and methylmercury between dissolved and particulate forms. Generally, dissolved mercury was highest in the reservoir epilimnion, while particulate mercury was highest in the hypolimnion. Total mercury appeared to decrease longitudinally through the reservoir. Dissolved and particulate methylmercury were highest in deeper waters. Fosness et al. (2013) reported a maximum value of 0.7 ng/L (0.0007 µg/L) near the bottom of the reservoir in spring 2012.

In 2013, IPC initiated a collaborative study effort with the USGS to better understand mercury dynamics in the HCC. The collaborative study is scoped for a 7- to 10-year timeline that began in 2014. The goals of the study are three-fold and employ an adaptive science strategy based on findings as the study moves forward.

The first goal is to define key processes and factors controlling spatial and temporal trends of mercury and methylmercury in surface water, sediment, and biota in the HCC. This goal is designed to define the key mercury processes for the HCC that influence methylmercury production, accumulation in the water column, and availability to biota. Specific areas of study relative to this goal include processes and factors that influence the uptake of methylmercury by biota at the base of the food web and dissolved and particulate organic carbon concentrations and composition. This goal will also help define the important spatial zones where these processes occur (e.g., epilimnion, thermocline, hypolimnion, sediments) and the important temporal periods during which uptake by biota may occur (e.g., spring runoff, summer, fall reservoir destratification). Processes and factors influencing the accumulation of methylmercury at the upper levels of the food web will also be studied, such as the relative importance of benthic vs. pelagic pathways and variations of food web structure across the HCC. The adaptive science strategy throughout the study will allow for the modification of the study based on previous findings and also the potential to observe how the processes are affected by different water-column conditions (e.g., temperature and DO structure, see Section 6.1. Temperature and 6.2. DO) that occur among different water years.

The information gathered through the first goal will be synthesized in the second goal, which is to develop a predictive model of the HCC that includes dominant processes of methylmercury production and bioaccumulation, and allows for scenario testing. The third goal includes developing applied science to help define the outcomes of various resource management alternatives to reduce methylmercury exposure to HCC food webs.

Currently this study combines integrated sampling that includes “repeat” sampling at fixed sites within the HCC and at inflow and outflow locations with “intensive” sampling campaigns at key times of the year. The objective of the repeat sampling is to assess temporal and spatial patterns in a subset of parameters (e.g., Total mercury, methylmercury, DOC, nutrients, zooplankton) and monitor the temperature and DO conditions in the HCC over the year. The repeat sampling is occurring biweekly or monthly. The objective of the intensive sampling is to provide detailed process-oriented measurements associated with mercury cycling in the water column and sediments to support model formulation (e.g., methylation, demethylation, volatilization, organic carbon composition) and detailed bioaccumulation data from zooplankton. Currently, the intensive sampling occurs twice a year.

6.6.2.2.2. Pesticides and Organic Compounds

Harrison et al. (2012) showed relatively low levels of toxic organic compounds throughout the water column in Brownlee Reservoir. The vast majority of over 470 analyzed compounds were reported as not detected. Seven compounds were reported as detected: 1) atrazine, 2) degradate desethyl atrazine, 3) alpha-chlordane, 4) chlorpyifos, 5) DDE, 6) dieldrin, and 7) endosulfan sulfate. All organic concentrations were below criteria established for the protection of aquatic life. Only DDE, dieldrin, and chlordane were near or above human-health criteria. These pesticides were detected below the limit of quantification and, therefore, the reported concentrations are only estimates that indicate the presence of the compound. Comparing levels of these compounds to established criteria is difficult because laboratory detection limits are higher than criteria, but results do show the presence of these compounds. Similar to t-DDT and dieldrin, chlordane has been banned for use since 1983.

6.6.2.3. Bed Sediment

6.6.2.3.1. Mercury and Methylmercury

Many researchers have reported detectable concentrations of mercury and methylmercury in Brownlee Reservoir bed sediments. Maximum reported total mercury concentrations were similar among the studies: 0.13 mg/kg (Clark and Maret 1998), 0.14 mg/kg (CH2MHill 2000), and 0.103 mg/kg (Fosness et al. 2013). Harris and Beals (2013) reported these values were within the range observed in northwest regional data. Reported methylmercury concentrations of 0.018 mg/kg (Fosness et al. 2013) were, however, higher than those reported in the region.

Current data from Brownlee Reservoir indicate Brownlee Reservoir sediments have average levels of total mercury but high levels of methylmercury (Harris and Beals 2013; Krabbenhoft 2012). For example, the median Brownlee Reservoir sediment concentration for total mercury is 82.1 ng/g, compared to an average for Idaho reservoirs of approximately 50 ng/g and approximately 85 ng/g for Washington state reservoirs (Figure 6.6-7). However, the median sediment methylmercury concentration (top 2 cm) for Brownlee Reservoir is 12.5 ng/g compared to methylmercury concentrations in Idaho, Oregon, and Washington reservoirs that range from approximately 0.5 to 1.7 ng/g (Figure 6.6-8).

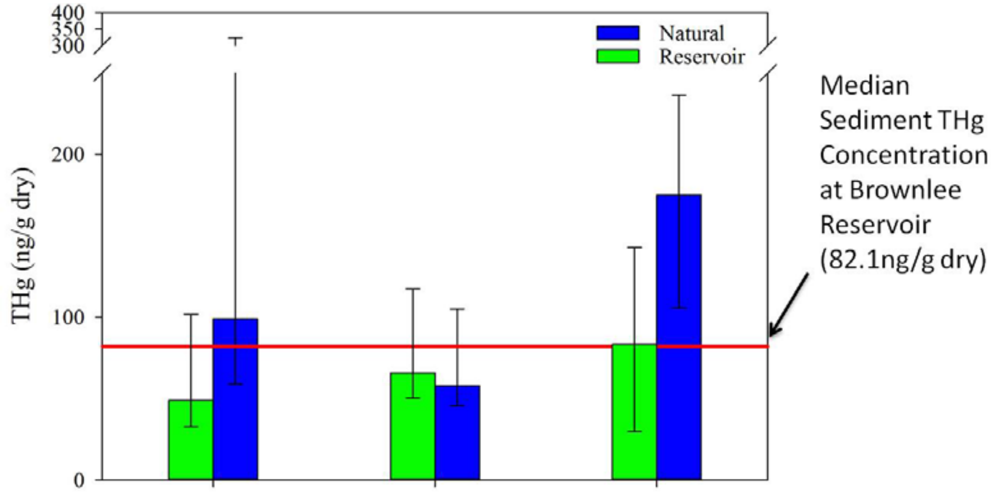


Figure 6.6-7
Total mercury in sediments in natural lakes and reservoirs. Data are from a 2007 regional EPA national lakes assessment. Values in red are the number of samples. The red line shows the median sediment total mercury concentration at Brownlee Reservoir of 82.1 ng/L dry. Adapted from Krabbenhoft 2012.

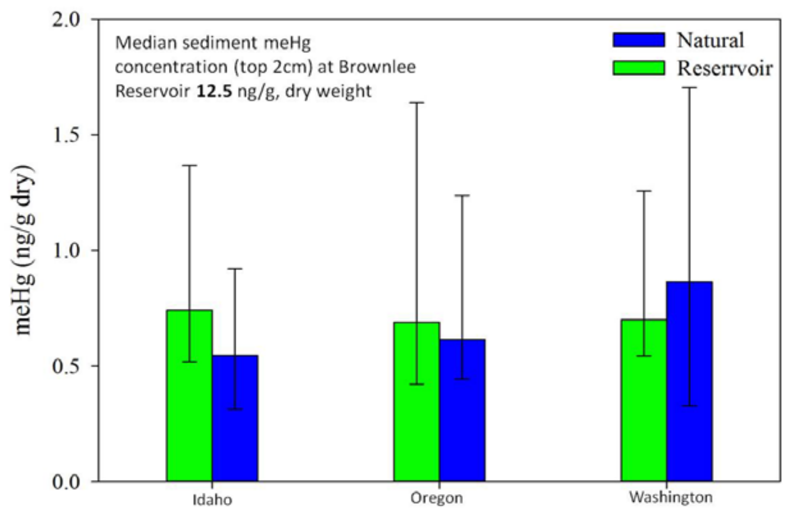


Figure 6.6-8
Methylmercury in the top 2 cm of sediments in natural lakes and reservoirs. Data are from a 2007 regional EPA national lakes assessment. Values in red are the number of samples. The median sediment methylmercury concentration (top 2 cm) at Brownlee Reservoir is 12.5 ng/g dry, which is too high to be shown on the chart. Adapted from Krabbenhoft 2012.

6.6.2.3.2. Pesticides, Organic Compounds, and Emerging Contaminants

In 2012, IPC and the USGS conducted sediment testing in Brownlee Reservoir for 526 toxics based on a list compiled in collaboration with the FWS, IDEQ, ODEQ, and others. Of those

526 toxics, 6 pesticides and organic compounds were detected: 1) propoxur (Baygon), 2) 2-4 dichlorobenzoic acid (2-4 D), 3) DDE, 4) promenton (TotalKill®), 5) glyphospate (Roundup®), and 6) pendimethalin (Fosness et al. 2013). Clark and Maret (1998) and CH2MHill (2000) also reported detectable concentrations of t-DDT and metabolites (i.e., DDE) in sediments. Similar to water-column organic toxics, most concentrations were less than reporting levels, which is useful to indicate the presence of the compound.

Fosness et al. (2013) also tested sediment for 57 wastewater compounds commonly known as emerging contaminates. Of the 57 compounds, 11 were present in Brownlee sediments, including 2,6,-dimethylnaphthalene (PAH), 3 beta coprostanol (fecal indicator), and 3 forms of plant steroid.

6.6.3. HCC Contribution to Toxics

Peterson et al. (2007) collected and analyzed over 2,700 large fish from more than 600 stream and river sites throughout 12 western states to assess regional distribution of mercury concentrations and correlate tissue concentrations with data on known point-source discharges of mercury. Finding no correlation with distribution, the authors concluded atmospheric transport is a key factor relative to mercury levels in fish across the western U.S. These findings suggested large-scale atmospheric transport, not local anthropogenic effects, was the key factor relative to mercury levels in fish across the western states. This conclusion is supported in Idaho by Essig and Kosterman (2008) and Essig (2010). They sampled mercury levels in fish throughout Idaho and concluded concentrations above the human-health criterion were widespread and common. They further reported that while providing a direct measure of human-health risk from the consumption of contaminated fish, looking at fish tissue provides no information on the origin of the mercury. Even in Salmon Falls Creek Reservoir, located in south-central Idaho where the IDEQ conducted an intensive study of mercury sources, definitive quantification and identification of discrete sources have remained elusive (Lay 2007). Identifying sources of mercury is difficult and involves intensive study, such as using isotopes to determine distinct methylmercury sources.

Brandt and Bridges (2007) evaluated water-column mercury concentrations flowing into and out of Brownlee Reservoir. They reported that most of the mercury entering Brownlee Reservoir was retained and noted that atmospheric deposition was not measured. They concluded the highest water-column mercury concentrations and loadings occurred during high-flow conditions, indicating a significant load to the HCC may be in particulate form. Clark and Maret (1998) and CH2MHill (2000) reported data indicating the retention of mercury in Brownlee Reservoir, likely a result of suspended sediment settling as velocity decreases. This corroborated with the interpretation of transport forwarded in the SR–HC TMDL (IDEQ and ODEQ 2004) that heavier sediments delivered to Brownlee Reservoir are contained in the reservoir and most of the mercury adsorbed or contained in those sediments is retained in Brownlee Reservoir. Harris and Beals (2013) further suggested that anoxic conditions that develop during late summer and fall in the hypolimnion of Brownlee Reservoir foster the highly efficient conversion of the inorganic mercury into methylmercury, with a possible accumulation of methylmercury in the hypolimnion during summer stratification.

6.6.3.1. Mercury TMDL

The SR–HC TMDL identified a need for a mercury TMDL (IDEQ and ODEQ 2004). To date, a mercury TMDL has not been developed. CH2MHill (2000) and Brandt and Bridges (2007) reported data useful to determine likely sources of mercury in the HCC and inflow tributaries.

6.7. Turbidity

Turbidity is an expression of the optical property of water that causes light to be scattered and absorbed rather than transmitted in straight lines (APHA 1999). Turbidity is frequently used as a surrogate measure of suspended inorganic particles; however, turbidity can be affected by organic particles, such as detritus and tannins. Neither Oregon nor Idaho has listed Snake River waters as being limited by turbidity (ODEQ 2014; IDEQ 2014) (tables 5.1-1 and 5.1-2).

6.7.1. Turbidity Standards

Oregon has a turbidity standard measured in nephelometric turbidity units (NTU). No more than a 10% cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity (OAR 340 041 0036). Idaho similarly identifies turbidity criteria relative to a background: “Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) NTU instantaneously or more than twenty-five (25) NTU for more than ten (10) consecutive days” (IDAPA 58.01.02.250.02.e.).

6.7.2. Conditions Relative to Turbidity

IPC has routinely measured turbidities in the Snake River and throughout the HCC in association with other water-quality monitoring efforts. The maximum turbidities, as measured between 1992 and 1997, were less than each immediately-preceding upstream reach of the Snake River (Table 6.7-1). A more representative measure is mean turbidity. Mean turbidities between 1992 and 1997 decreased from 39 NTU inflow to Brownlee Reservoir to 13.5 NTU in the reservoir, a 65% reduction. A similar percent of reduction occurred in Oxbow Reservoir, resulting in a mean turbidity of 4.1 NTU. Turbidities remained low throughout the remainder of the HCC and in the Snake River downstream of HCD.

Table 6.7-1
Minimum, maximum, and mean turbidity measures in NTUs for various reaches of the Snake River from 1992 through 1997 and the 10% cumulative increase threshold (thres.) as allowed by Oregon statute (OAR 340-041-0036)

	Snake River Upstream (RM 409–343.1)		Brownlee Reservoir (RM 343–284.6)		Oxbow Reservoir (RM 284.5–272.5)		Hells Canyon Reservoir (RM 272.4–247.6)		Snake River Downstream (RM 247.5–247)	
	NTU	**Thres.**	**NTU**	**Thres.**	**NTU**	**Thres.**	**NTU**	**Thres.**	**NTU**	**Thres.**
Count	213.0	–	978.0	–	265.0	–	434.0	–	174.0	–
Minimum	0.9	1.0	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6
Maximum	291.0	320.1	213.0	234.3	50.2	55.2	48.9	53.8	41.7	45.9
Mean	39.0	42.9	13.5	14.8	4.1	4.5	5.4	6.0	5.0	5.5

6.7.3. HCC Contribution to Turbidity

IPC does not contribute to turbidity in the Snake River. The HCC actually reduces turbidity through settling suspended inorganic and organic solids.

6.8. TDS

TDS is a measure of dissolved ions in water that includes the major inorganic ions (e.g., calcium, magnesium, sodium, potassium, chloride, sulfate, carbon, and bicarbonate) and other trace soluble organic and inorganic materials. Neither Oregon nor Idaho has listed the Snake River or the HCC as limited (ODEQ 2014; IDEQ 2014) (tables 5.1-1 and 5.1-2). TDS data were not frequently available; however, limited analysis indicated the TDS criterion was exceeded both in the Snake River immediately upstream of the HCC as well as below.

6.8.1. TDS Standards and SR–HC TMDL Targets

Oregon has a TDS criterion not to exceed 100 mg/L unless otherwise authorized by the ODEQ (OAR 340-041-0032). Idaho does not have a criterion specific to dissolved ions, nor did the SR–HC TMDL identify a TDS target (IDEQ and ODEQ 2004).

6.8.2. Conditions Relative to TDS

IPC has periodically measured TDS in the Snake River and throughout the HCC in association with other water-quality monitoring. TDS concentrations measured in 1992 and 1995 exceeded the Oregon criterion both above and below the HCC. In 1992, levels inflowing to the HCC averaged 321 mg/L, while the levels in the Hells Canyon Reservoir outflow averaged 301 mg/L (Table 6.8-1). In 1995, levels inflowing to the HCC averaged 335 mg/L, while levels in the Brownlee Reservoir outflow averaged 285 mg/L. Outflow average and maximum TDS levels were lower than inflow levels.

Table 6.8-1
Minimum, maximum, and mean TDS concentrations in mg/L for inflow, Brownlee Reservoir outflow, and Hells Canyon Reservoir outflow in 1992 and 1995

	1992			1995		
TDS Concentrations	Inflow (RM 330) (mg/L)	Brownlee Reservoir Outflow (RM 284.4) (mg/L)	Hells Canyon Reservoir Outflow (RM 247) (mg/L)	Inflow (RM 340) (mg/L)	Brownlee Reservoir Outflow (RM 284.4) (mg/L)	Hells Canyon Reservoir Outflow (RM 247) (mg/L)
Count	9	7	7	10	11	NA
Minimum	240	265	274	173	138	NA
Maximum	375	340	325	450	413	NA
Mean	321	309	301	335	283	NA

Note: NA = Data not available.

6.8.3. HCC Contribution to TDS

TDS levels in the HCC are affected by sources to, and losses from, the reservoir complex, as well as the abiotic process within the reservoirs. The inputs include TDS inflowing the HCC, wet and dry precipitation (i.e., rainfall and wind-blown dust), and the weathering of soils and rock. While precipitation has not been assessed, it is expected to be relatively low. Weathering would be expected to exceed precipitation but still be much less than inflowing loads. A likely primary source contributing to the high inflow loads is runoff from surface irrigation. Losses from the HCC would include an outflow of surface water and a much smaller loss related to groundwater discharge.

Besides the abiotic processes discussed previously, biotic uptake and release can also affect TDS levels. Biological processing of organic matter releases TDS, while primary and secondary production uptakes constituents included in TDS.

TDS levels in the HCC are likely primarily related to levels in the Snake River inflow to Brownlee Reservoir or sources not associated with the HCC. Therefore, as levels in the Snake River and other tributaries are reduced and attain the criterion, TDS levels in the HCC and Snake River downstream should be reduced similarly. As previously stated, TDS is a measure of dissolved ions in water. While TDS is not a measure of sediment or organic matter, it can be assumed that some portion of TDS is derived from these constituents. Therefore, as sediment and organic matter are reduced, TDS levels will be correspondingly reduced. TMDLs upstream of the HCC have an established sediment and nutrient load and waste load allocations. These allocations, in part, targeted the reduction of runoff from surface irrigation. Therefore, as these TMDLs are implemented, dissolved ions (i.e., TDS) will be reduced.

6.9. Bacteria

Neither Oregon nor Idaho has listed Snake River waters as being limited by bacteria (ODEQ 2014; IDEQ 2014) (tables 5.1-1 and 5.1-2). A bacteria analysis has shown that available data do not exceed criteria, and designated recreational uses are not impaired (IDEQ and ODEQ 2004).

6.9.1. Bacteria Standards and SR–HC TMDL Targets

The SR–HC TMDL bacteria target is Oregon and Idaho’s (except “specified public swimming beaches”) criteria to protect recreational uses. Specifically, no single sample may exceed 406 E. coli organisms per 100 ml or a 30-day logarithmic mean of 126 E. coli organisms per 100 ml, based on a minimum of 5 samples.

6.9.2. Conditions Relative to Bacteria

The SR–HC TMDL evaluated bacteria data and reported no samples exceeded the criteria (IDEQ and ODEQ 2004). They concluded bacteria did not impair the recreational uses of the Snake River or the HCC.

6.9.3. HCC Contribution to Bacteria

IPC does not contribute to the bacteria of surface waters. The treated sanitary sewage disposal associated with the Brownlee Project was permanently eliminated on May 26, 2001. It was replaced with a new, upland on-site disposal (septic) system permitted through the IDHW SWDHD. The ODEQ has permitted (OR 002727-8) a sewage holding tank for the Hells Canyon Project. As such, no treated or untreated sewage is disposed directly to surface waters of Oregon or Idaho.

Associated with the HCC, IPC maintains several comfort stations that include showers, restrooms and vault toilets, and RV dump stations (Table 2.3-1). Similarly, there is no treated or untreated wastewater discharged directly to surface waters of Oregon or Idaho. The largest facility, Woodhead Park, which was developed in 1994, disposes effluent by a land-application treatment system meeting IDEQ standards.

6.10. Biocriteria

In addition to the specific numeric criteria addressed previously, the ODEQ established a general biological criteria (biocriteria) standard that requires all waters to be "of sufficient quality to support aquatic species without detrimental changes in the residential communities" (OAR 340-041-0011). This general standard is addressed through each of the more-specific numeric criteria, targets, and allocations. Therefore, reasonable assurance that water quality is sufficient to support aquatic species without detrimental changes in the residential communities is inherent in the reasonable assurance that numeric criteria will be met.

6.11. Narrative Standards

The ODEQ has numerous narrative standards (i.e., descriptive standards for the protection of designated beneficial uses). In general, narrative standards strive to provide the best water quality given "the highest and best practicable treatment and/or control of wastes, activities, and flows" (OAR 340-041-0007(1)). Neither Oregon nor Idaho has identified Snake River waters as limited relative to narrative standards (ODEQ 2014; IDEQ 2014) (tables 5.1-1 and 5.1-2).

6.11.1. Narrative Standards and SR–HC TMDL Targets

Oregon narrative standards address many activities that do not directly apply to a § 401 application for the HCC (e.g., logging and forest-management activities). The following are narrative standards directly related to water-quality certification associated with the HCC:

- For any new waste sources, alternatives that utilize re-use or disposal with no discharge to public waters must be given the highest priority for use wherever practicable. New source discharges may be subject to the criteria in OAR 340-041-0004(9) and OAR 340-041-0007(4).

- No discharges of wastes to lakes or reservoirs may be allowed except as provided in OAR 340-041-0004(9) and OAR 340-041-0007(5).

- Road building and maintenance activities must be conducted in a manner to keep waste materials out of public waters and minimize the erosion of cut banks, fills, and road surfaces (OAR 340-041-0007(9)).
- The development of fungi or other growths having a deleterious effect on stream bottoms, fish, or other aquatic life, or that are injurious to health, recreation, or industry may not be allowed (OAR 340-041-0007(11)).
- The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish may not be allowed (OAR 340-041-0007(12)).
- The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed (OAR 340-041-0007(13)).
- Objectionable discoloration, scum, oily sheens, or floating solids or the coating of aquatic life with oil films may not be allowed (OAR 340-041-0007(14)).
- Aesthetic conditions offensive to the human senses of sight, taste, smell, or touch may not be allowed (OAR 340-041-0007(15)).
- Radioisotope concentrations may not exceed maximum permissible concentrations in drinking water, edible fish or shellfish, wildlife, irrigated crops, and livestock and dairy products or pose an external radiation hazard (OAR 340-041-0007(16)).

6.11.2. Conditions Relative to Narrative Standards

As stated in OAR 340-041-0007(1), the intent of narrative standards, notwithstanding numeric criteria, is to “maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels.” As such, conditions relative to narrative standards have been addressed in preceding discussions of conditions relative to numeric criteria.

6.11.3. HCC Contribution to Narrative Standards

Narrative standards relevant to the HCC relate to the discharge of wastes to public waters; nuisance growths and the formation of organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry; oily sheens or the coating of aquatic life with oil films; the creation of tastes, odors, or other toxic conditions; and land-management activities.

Narrative standards have been addressed in previous sections of this application or point-source permits specific to point-source discharge activities. The discharge of wastes to public waters is addressed by specific point-source discharge permits for appropriate HCC-related activities that are issued by the EPA and ODEQ. IPC does not directly discharge treated or untreated sanitary wastes to surface waters (see Section 6.9.3. HCC Contribution to Bacteria). The SR–HC TMDL addressed narrative standards associated with nuisance growths and the formation of organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry. IPC has identified its contribution in Section 6.4.3. HCC Contribution to Nuisance Algae. The EPA and ODEQ point-source discharge permits address oily sheens or the coating of aquatic life with oil films. IPC must not exceed levels or requirements as stated in permits. The creation of tastes, odors, or other toxic conditions are discussed in Section 6.6. Toxics. IPC will cooperate in the development of the mercury TMDL and implement appropriate measures to address its allocations. The *Hells Canyon Resource Management Plan*, developed by IPC as part of the HCC license application to FERC, establishes guidelines for the management of its lands. Road building and maintenance activities and aesthetic-condition narrative standards are addressed directly in the *Hells Canyon Resource Management Plan*, while other narrative standards are indirectly addressed. Exhibit 4.3-2 discusses compatibility with local land-use plans.

7. Proposed PME Measures

7.1. Temperature Proposed Measures

7.1.1. The SR–HC TMDL and the HCC Temperature Load

The SR–HC TMDL assigned a load allocation to the HCC to address temperature conditions below HCD during the salmonid spawning period when flows into Brownlee meet the downstream salmonid spawning standard. While recognizing the HCC is not a heat source, the SR–HC TMDL determined the HCC delays fall cooling downstream of HCD to the extent that if water flowing into Brownlee Reservoir met the upstream summertime cold-water biota standard, outflows from the HCC would still exceed the applicable standard by a “small margin.” The SR–HC TMDL summarized the narrative temperature load allocation assigned to the HCC as follows:

> To address violations of the water quality criteria for salmonid spawning temperatures, a thermal site-potential for water downstream of Hells Canyon Dam was established as the water temperature at RM 345 (approximately 10 miles upstream of Farewell Bend) using data from 1991 to 2001. A temperature load allocation in the form of a required temperature change at Hells Canyon Dam was identified as a change in water temperature such that the temperature of water released from Hells Canyon Dam is less than or equal to the water temperature at RM 345, or the maximum weekly maximum temperature target of 13 °C for salmonid spawning, plus the allowable temperature change defined as no greater than 0.14° C. The entire load for the Downstream Snake River segment (RM 247 to 188) is allocated to the Hells Canyon Complex of dams owned and operated by IPCo. Specific compliance parameters for meeting this load allocation will be defined as part of the 401 Certification process.

Key objectives of the SR–HC TMDL include attainment of water-quality standards through the “fair and equitable distribution” of pollutant loads and the development of a phased and iterative implementation process that allows for the adjustment of water-quality targets and load allocations to better meet the needs of designated beneficial uses. The SR–HC TMDL explains that due to the sparseness of data and also the size and complexity of the watershed, implementation of the SR–HC TMDL would necessarily be an iterative process with the attainment of water-quality standards occurring over a period of several decades, requiring significant, long-term and coordinated efforts from all pollutant sources in the watershed.

The purpose or designated beneficial use for the temperature standard below HCD is the protection of SRFC spawning. SRFC were listed as threatened under the ESA on April 22, 1992. The SR–HC TMDL found that data available at the time (2004) did not indicate SRFC spawning below HCD was impaired by water temperatures in excess of the spawning standard during the spawning period. More recent data, including the record before the IDEQ supporting the approval of Idaho's site-specific criteria on March 29, 2012, confirms that the current temperature regime below HCD does not present an identifiable or immediate risk to salmonid spawning.

NOAA Fisheries determined that "the current water temperature regime downstream from HCD is more beneficial to SRFC than the natural regime, primarily due to warmer fall and winter temperatures that accelerate fry emergence."[34] The fact that this beneficial use is supported under current conditions provides the opportunity to address the HCC temperature load allocation in an adaptive manner to ensure SRFC spawning remains protected and other aquatic resources are not adversely impacted by abrupt or unintended changes in water quality or habitat conditions below the HCC.

7.1.2. The Temperature Management and Compliance Plan

In this application, IPC proposes to address the HCC temperature obligation through a comprehensive TMCP that will include as its centerpiece the development and implementation of upstream Snake River mainstem and tributary measures that provide temperature, water-quality, and habitat benefits to the Snake River above, within, and below the HCC (the SRSP). The TMCP will also include adaptive management, monitoring and reporting components, and, as needed, consideration of alternative or supplemental measures to facilitate the efficient implementation and management of the SRSP and provide reasonable assurance that the HCC cumulative thermal load exceedance will be achieved. IPC expects that the monitoring and reporting components of this program would be developed in post-certification implementation planning with the DEQs. This section of the application provides an overview of the TMCP, the proposed SRSP, and how through that program there will be reasonable assurance that the temperature obligation assigned to the HCC will be addressed. IPC will submit a final TMCP for DEQ review and approval within 120 days after FERC license issuance.

The SRSP was developed in consultation with The Freshwater Trust (TFT), a 501(c)(3) non-profit organization with extensive experience in preserving and restoring freshwater ecosystems. IPC has worked closely since 2012 with TFT to develop and study the details of the

[34] See January 27, 2011, NOAA Fisheries letter to the IDEQ and ODEQ, p. 6.

SRSP. The SRSP will include a variety of restoration actions to generate thermal benefits. The 3 actions currently prioritized include 1) in-stream habitat restoration projects in the Snake River from near Walters Ferry downstream to Homedale, Idaho—a distance of 33 miles, 2) riparian revegetation projects in the tributaries of the Snake River, and 3) the pursuit and implementation of in-stream flow augmentation opportunities in the tributaries. In this latter context, IPC will continue to explore methodologies to better quantify thermal benefits from any flow augmentation actions.

The primary objective of the SRSP is to reduce thermal loading to the Snake River and its tributaries. On the mainstem Snake River, this will be accomplished through in-river projects that narrow and deepen the river channel, thereby increasing water velocity and decreasing solar input through reduced surface area. Increased water velocity and decreased solar input will result in less thermal loading to the water, thereby improving in-river water temperature conditions. Additionally, to reduce thermal loading in the major tributaries to the Snake River, IPC will implement riparian enhancements that block solar thermal load to the tributary water and explore opportunities for flow enhancement to buffer and ameliorate in-stream temperature conditions.

The SRSP also provides important localized habitat benefits not directly related to meeting the temperature load assigned to IPC by the SR–HC TMDL. In an attempt to ensure that the thermal and habitat benefits of the program will be long-standing, IPC will maintain implemented project sites and implement project stewardship actions to reduce sediment and nutrient loading from agricultural activities within the reach of the Snake River where the in-river habitat activities would be conducted for the term of the FERC license. The combination of these actions would also reduce available habitat for aquatic macrophytes. Similarly, the tributary work that is primarily designed to reduce thermal loading will improve both water-temperature conditions of the tributary flows coming into the Snake River and also improve and enhance habitat conditions in the tributaries.

While the benefits of the SRSP will benefit the Snake River system as a whole, the program will also address the temperature load assigned to the HCC by the SR–HC TMDL by providing sufficient thermal benefits upstream of the HCC to offset the cumulative thermal load exceedance at the discharge of HCD.

7.1.2.1. Addressing the Salmonid Spawning Temperature Load through a Thermal Load Offset Framework

The SR–HC TMDL provided a narrative description of this temperature load, providing that specific compliance parameters for meeting the load allocation would be developed as part of the 401 certification process. The primary objective of the proposed SRSP is to implement measures upstream of the HCC (in-river and within tributaries) that will provide aggregate thermal benefits sufficient to offset the cumulative thermal load exceedance below HCD during the spawning period. This cumulative thermal load exceedance is the amount, expressed in bkcals, by which the temperature of the water discharged at HCD during the salmonid spawning period exceeds the 7DAM temperature criterion of 13.3°C. (See Section 6.1.1.4. Salmonid Spawning for a detailed description of the salmonid spawning criteria.). The cumulative thermal load exceedance is then increased by attenuation ratios and safety factors, which results in the total aggregate thermal benefits that must accrue at the inflow to the HCC.

The initial step in the process of determining the quantity of thermal benefits the SRSP must produce to achieve this offset is establishing the cumulative thermal load exceedance at the outflow of HCD for the period during the spawning season that the HCD discharge exceeds the standard. Section 6.1.2.3.2. Salmonid Spawning of this application provides specifics as to how this exceedance was calculated. Generally, it involves 2 variables: 1) the amount, in °C, by which the water temperature of the outflows on a given day exceeds the applicable water-quality standard, and 2) the amount of water flow discharged from HCD on that day. For each of the 22 years of data analyzed, these calculated daily values are then combined to get a cumulative thermal load exceedance for that year's spawning period. Because annual cumulative thermal load exceedances ranged from 0.0 to 1,044.9 billion kilocalories (Table 6.1-5) over this 22-year period, IPC proposes to use the 90th percentile value of the 22-year dataset to represent this cumulative exceedance (see Section 6.1.2.3.2. Salmonid Spawning).

While the water temperature and the flow discharges can vary on a given day, the one constant in the calculation of a daily thermal load exceedance is the applicable water-quality standard. Despite the fact that Idaho adopted and submitted a site-specific criteria of 14.5°C in 2012 the EPA has not yet acted on Idaho's criteria change. Therefore, the applicable standard for 401 certification at this time is the Oregon standard, which is 13°C. As explained in Section 6.1.1.4. Salmoid Spawning, IPC is proposing to use 13.3°C as the applicable standard.

As detailed in Section 6.1.2.3. Outflow Temperature, when using 13.3°C as the applicable standard, the cumulative thermal load exceedance at the outflow of HCD is 550.7 bkcal. The narrative description of the HCC temperature load in the SR–HC TMDL includes a 10% margin of safety (55.1 bkcal), which increases the cumulative thermal load exceedance to 605.8 bkcal when added to this calculation. This is the cumulative thermal load exceedance that represents the excess thermal load relative to 13.3°C.

Following the determination of the HCC outflow cumulative thermal load exceedance, 3 steps remain in the offset framework.

1. Determine and apply a reservoir attenuation factor (i.e., the proportion of upstream thermal benefits that are reasonably expected to travel from the HCC inflow to the HCC outflow).
2. Determine and apply river attenuation factors. (i.e., what proportion of thermal benefits generated by in-river and tributary measures can reasonably be expected to travel from project sites to the HCC inflow).
3. Determine and apply a thermal benefit aggregation, and aggregation time period.

After applying step 1 above, in this framework, the required HCC outflow cumulative thermal load can be expressed as an aggregate thermal load target needed at the HCC inflow. The term "aggregate" is used at this point in the framework because offsetting this load will be accomplished through the aggregation of project-specific thermal benefits from multiple upstream SRSP projects after considering both the spatial (step 2 above) and temporal (step 3 above) relationship of those benefits to the HCC inflow. Each of the steps in this framework are explained in more detail below.

7.1.2.1.1 Step One—Reservoir Attenuation

Because IPC's proposal to offset the HCC outflow cumulative thermal load exceedance uses upstream watershed based projects, attenuation of the upstream thermal benefits that occurs in the HCC reservoirs must be taken into account. Attenuation here is defined as a decrease in thermal benefits that occurs as water moves through the reservoirs due to reservoir processes such as mixing, storage timing, and warming. To account for reservoir attenuation, IPC has employed the best available data, including water-quality modeling specific to the HCC, to estimate an appropriate attenuation factor. After analysis (see Section 7.1.2.1.4. Technical Information Relative to Attenuation and Thermal Benefit Aggregation Period) and in consultation with the DEQs, IPC concludes that using an attenuation factor of 50% (half of the thermal benefits provided at the inflow to the HCC will not be expressed at the HCC outflow during the salmonid spawning period) reasonably accounts for the attenuation of upstream thermal benefits caused by the HCC reservoirs. Applying this HCC reservoir attenuation factor to the cumulative thermal load exceedance at HCD (605.8 bkcal with the margin of safety included) results in an aggregate thermal load reduction target of 1211.6 bkcal at the HCC inflow. This is the aggregate thermal load reduction the SRSP must provide in the inflow to the HCC.

7.1.2.1.2. Step Two—River Attenuation of Upstream SRSP Thermal Benefits

Similar to the need to address attenuation through the HCC reservoirs, there is also a need to address attenuation of thermal benefits from each project to the inflow to the HCC. This task, however, is complicated by the fact that SRSP measures would be implemented throughout the watershed upstream of the HCC, and as a result, decreases in thermal loading from specific projects will vary depending on the distance of the project from the HCC inflow. As with the HCC reservoir attenuation analysis, IPC used the best available data in determining an appropriate attenuation factor for the upstream SRSP thermal benefits. Because of the complexity of tracking individual parcels of water through the riverine reaches between project areas and the HCC and the diversity of project locations within the watershed, IPC is proposing to use 1 attenuation factor for tributary projects, and 1 for in-river projects. To determine these 2 attenuation factors, IPC, along with the DEQs, examined CE-QUAL-W2 modeling conducted by Portland State University (Berger et al. 2009) and also by IPC. Based on this examination (see Section 7.1.2.1.4.) a reasonable attenuation factor 1) for thermal load reductions realized from projects within the Snake River from Swan Falls Dam downstream to Homedale, Idaho is 22%, and 2) for tributary projects is 25%. In other words, in-river and tributary project thermal benefits will be reduced by 22% and 25%, respectively, before being applied or credited toward the aggregate thermal load target of 1211.6 bkcal at the HCC inflow.

7.1.2.1.3 Step Three—Thermal Benefit Aggregation and Aggregation Time Period

As described in Section 6.1.2.3.2.1. Calculation Methodology and Results, by summing all observed daily thermal load exceedances into a cumulative thermal load exceedance for a year, IPC accounts for the entirety of the excess pollutant load (magnitude) observed during the spawning period (duration) at the HCC outflow. The SRSP projects are intended to offset this cumulative thermal load exceedance by producing thermal benefits at many individual projects upstream. Therefore, the thermal benefits from all upstream SRSP projects will be added together (i.e., aggregated), attenuated to reflect Steps 1 and 2, then compared against the cumulative thermal load exceedance at the outflow.

The last step in determining how to apply the thermal benefits of SRSP projects toward the HCC outflow cumulative thermal load exceedance is to determine the temporal duration of the SRSP thermal benefits. In other words, for what period of time will the SRSP measures provide thermal benefits that can reasonably be expected to influence the HCC outflow cumulative thermal load exceedance during the fall spawning period? While the measures to be implemented under the SRSP will provide thermal benefits year round, IPC is proposing that only the thermal benefits that have a sufficient effect, or nexus, to the salmonid spawning period at the HCD outflow be aggregated and applied toward the offset.

In an effort to determine this aggregation time period, IPC, in consultation with the DEQs, used CE-QUAL-W2 modeling of inflow thermal load reductions during September and October and incrementally simulated additional thermal benefits through the prior months back to April. The results (described in detail in Section 7.1.2.1.4. Technical Information Relative to Attenuation and Thermal Benefit Aggregation Period) of this modeling indicate that thermal load benefits entering the HCC from April through October result in quantifiable benefits realized at HCD outflow during the salmonid spawning period. While the thermal benefits from water entering the HCC from April through June do produce a benefit at the outflow from the HCD during the salmonid spawning period, the magnitude of that benefit at the HCD outflow is smaller than the benefits realized from the later months. These model runs show that July through October inflow best represents the make-up of thermal benefits realized at the HCD outflow during the salmonid spawning period. As a result, IPC is proposing that the thermal benefits provided by the SRSP measures during the period from July 1 through October 29 be summed and credited toward the offset of the HCC outflow cumulative thermal load exceedance.

The selection of July 1 through October 29 as the aggregate thermal benefit period is also consistent with the HCC system dynamics and conclusions relative to those system dynamics in the SR–HC TMDL. Many thermal benefits generated upstream of the HCC may not translate immediately through to the HCC outfall on a daily basis. Rather, because of this complicated and delayed storage, retention, and release dynamic, the thermal benefits associated with water that has entered the HCC between the beginning of July and the end of October have a reasonable nexus to the thermal loading downstream of the HCC during SRFC spawning. The TMDL notes that water may reside in the HCC for over four months, or just a number of days, and water that enters the HCC may stratify over time. As such, the thermal benefits associated with the July, August, September, and October water that enters the HCC has an effect on the discharges occurring in late October and early November during the period of concern for spawning.
The summer period, including July when upstream water temperatures typically peak, was also identified in the SR–HC TMDL as a critical period for temperature loading upstream of the HCC (TMDL at 367–369). Therefore, it is reasonable to include the thermal benefits associated with SRSP measures during this period of greatest heat loading to the system.

7.1.2.1.4. Technical Information Relative to Attenuation and Thermal Benefit Aggregation Period

As mentioned in the previous sections, a collection of results from CE-QUAL-W2 temperature modeling were considered to inform the selection of attenuation factors and the aggregation time frame. This section provides more detail on that modeling.

7.1.2.1.4.1. Model Background

To support the FERC license application process, IPC developed CE-QUAL-W2 models for Brownlee, Oxbow, and Hells Canyon reservoirs (Harrison et al. 1999; Zimmerman et al. 2002). Models were initially developed for 1992, 1995, 1994, 1997, and 1999. These years were selected based on water-year conditions combined with data availability for set-up and calibration. The initial calibration effort was focused on 1992, 1995, and 1997 for low, medium and high water years, respectively. The 1994 and 1999 models represent medium-low and medium-high water years, respectively. The 1994 and 1999 models were developed as verification years (e.g., the model settings developed through calibration of the other years were applied to these years). The general calibration process for the HCC models is described in Harrison et al. (1999) and Zimmerman et al. (2002). The majority of the calibration effort was focused on conditions in Brownlee Reservoir where physical and biological processes are more complex. Also, field studies consistently show that conditions in Oxbow and Hells Canyon Reservoirs are driven by Brownlee outflow conditions.

In 2002, a large data collection effort by IPC and others provided additional information relative to inflowing Snake River organic matter, including algae (Harrison 2005). Also studied were Brownlee hydrodynamics, temperature stratification, DO dynamics, meteorological conditions, and intake channel configuration (Botelho et al. 2003, Botelho and Imberger 2007). A 2002 CE-QUAL-W2 model was developed using this additional information, which reduced uncertainty relative to boundary conditions for the existing low-water year model (i.e., 1992). After the 2002 model was developed, many of the updates and improvements were then applied to the other model years, and calibration for all the years was re-evaluated. IPC used several methods to analyze model output and improve the calibration, including animations of the water-quality constituents over time, time-series plots of the outflow constituents and isopleths and profile plots at various locations and times in the reservoir. IPC also used absolute mean error analysis as a quantitative means of assessing in-reservoir calibration. Measured temperature collected at multiple depths and locations in the reservoir were compared with modeled values and summarized to show the overall error over the year.

The HCC models have been recently been upgraded to CE-QUAL-W2 Version 3.7. As part of this upgrade process, the settings for all the models were reviewed, and changes were made where applicable. Specific to temperature settings, 2 changes were made to the Hells Canyon model, including resetting evaporation coefficients to default values and updating the bathymetry to include the old coffer dam that remains in place upstream of HCD. The resulting temperature calibration for the Hells Canyon outflow temperature is shown in Figure 7.1-1 and Figure 7.1-2.

For the HCC reservoir modeling analysis presented in the following sections, 2 of the 6 years (1992 and 2002) are used. Both of these years represent low water conditions. Using low-water year models allows the evaluation of conditions when the largest exceedances of the salmonid spawning criterion are typically seen in historical data.

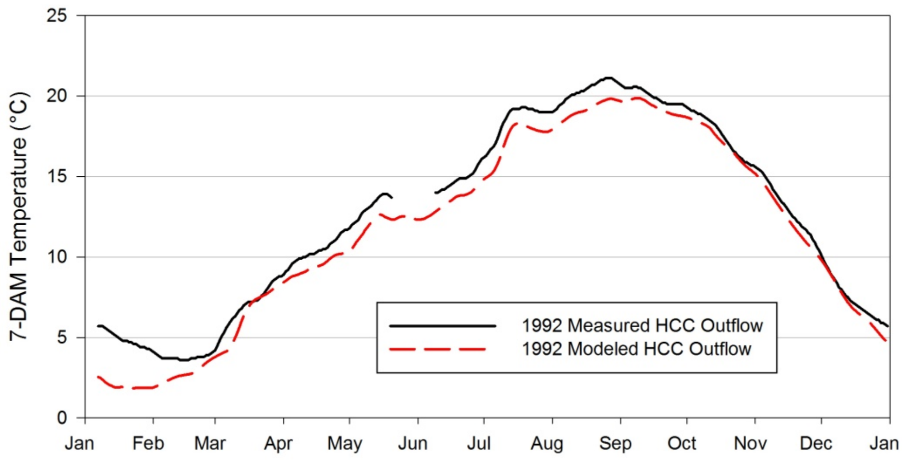


Figure 7.1-1.
Modeled Hells Canyon outflow 7DAM compared with measured 7DAM for the 1992 CE-QUAL-W2 model

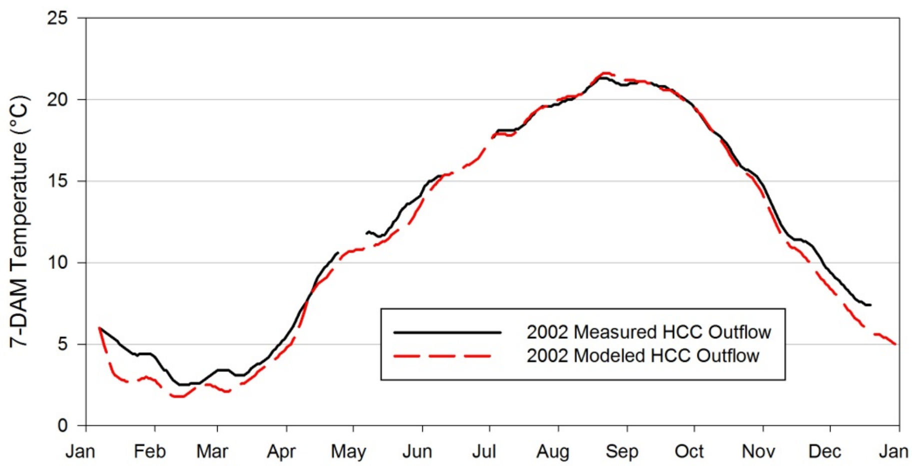


Figure 7.1-2.
Modeled Hells Canyon outflow 7DAM compared with measured 7DAM for the 2002 CE-QUAL-W2 model

IPC used a Snake River CE-QUAL-W2 model, developed for 1995 by IPC and used in the SR–HC TMDL development process (Harrison et al. 2000), along with modeling conducted by Portland State University (Berger et al. 2009), to inform the decision relative to thermal load attenuation through the free-flowing mainstem Snake River and tributaries. The 1995 Snake River model includes an approximately 150-mile stretch of the Snake River from C. J. Strike Dam (RM 494) to Brownlee Reservoir inflow (RM 340). The model was specifically developed to support the analysis and development of Snake River TP targets and a Brownlee Reservoir DO allocation. The model was developed for 1995 because substantial data were available to support model development in that year and because 1995 represented "average" flow conditions, which is consistent with the SR–HC TMDL focus on average water conditions.

The calibration process for the 1995 Snake River model is described in Harrison et al. (2000). The model simulated temperature conditions reasonably well throughout the year (Figure 7.1-3). The most accurate simulated temperature appears to occur at the Brownlee inflow (i.e., Porters RM 340) and near the downstream end of the Marsing reach (i.e., Adrian RM 403). At other locations, the model values appeared warmer than measured values, especially during spring months.

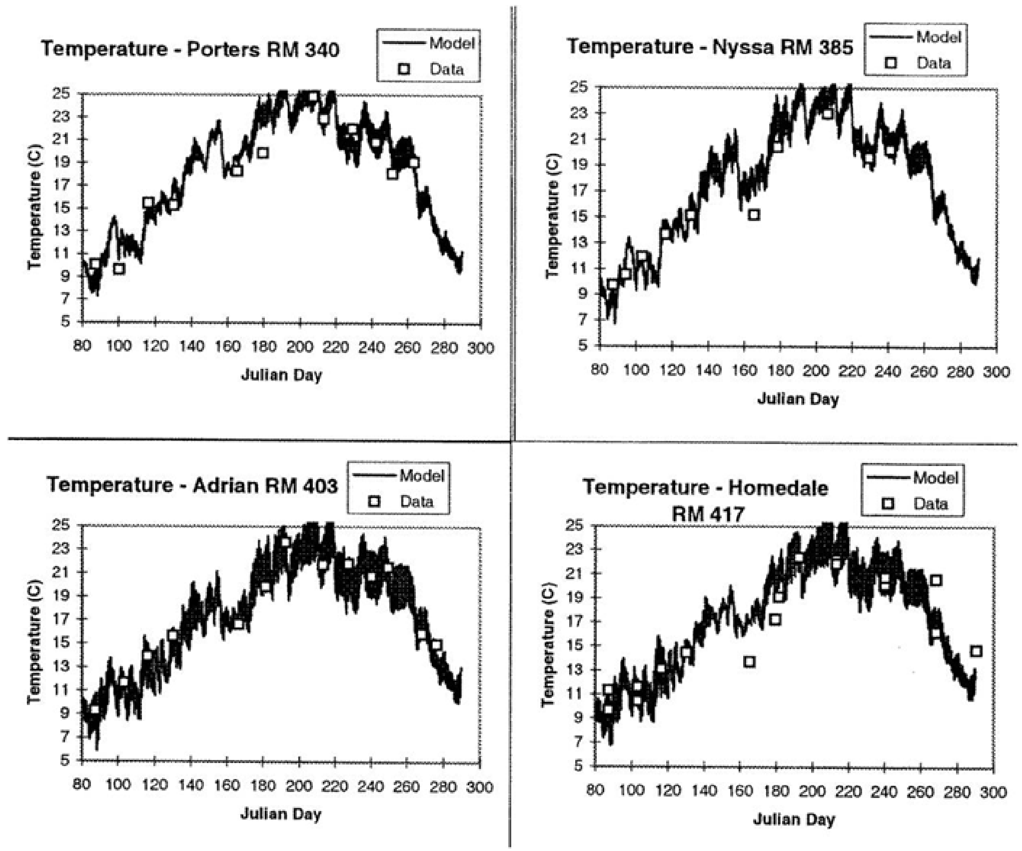


Figure 7.1-3.
1995 Snake River modeled temperature compared with measured at 4 locations in the Snake River. Figure from Harrison et al. (2000).

7.1.2.1.4.2. Reservoir Attenuation and Time Period

The 1992 and 2002 CE-QUAL-W2 reservoir models were used in a sensitivity analysis to help evaluate both the effect of time frame and attenuation of inflowing thermal load reductions on outflow thermal load reductions during the salmonid spawning period. A series of four model runs were developed starting with an equal per day inflow temperature reduction during September through October, then increasing the time frame by month back to July and then to April (Figure 7.1-4). This resulted in 4 model runs with inflow temperature reductions for each of the 2 model years (1992 and 2002): 1) September through October, 2) August through October, 3) July through October, and 4) April through October. The objective of modeling a 2°C equal per day temperature reduction over these 4 time periods was to explore which of the 4 inflow time frames best represented the make-up of thermal benefits realized at the HCD outflow during the salmonid spawning period. These modeling results also assist in identifying the proportion of the inflowing thermal load reductions that are translated to the outflow (i.e., reservoir attenuation). As noted above, the results of these model runs informed the selection of attenuation factors and aggregation time frame.

7.1.2.1.4.2.1. Time Period

The selection of an aggregate thermal benefit time period is based on the results of the 1992 and 2002 CE-QUAL-W2 reservoir models, as well as other qualitative information relevant to the dynamics of the HCC.

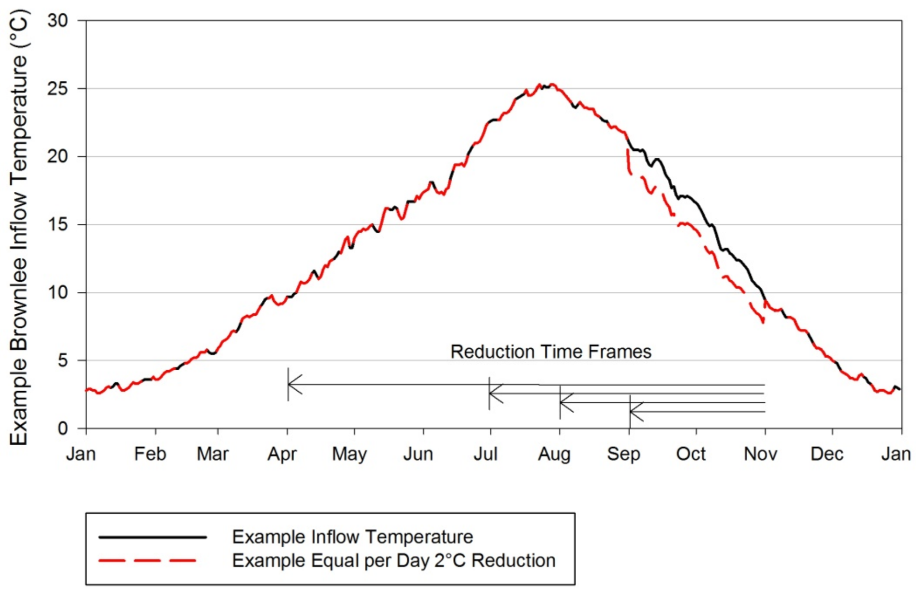


Figure 7.1-4.
Example inflow temperature series showing an example 2°C equal per-day temperature reduction over the September 1 through October 29 time frame and arrows indicating the other time frames that were modeled.

In these 4 model runs, the Brownlee inflow thermal load reduction was calculated based on an assumed example temperature reduction (i.e., 2°C per day) and the historical measured average flow over the time frame for each year. An equal per day approach was selected as the most straightforward method to apply the temperature reduction for modeling sensitivity purposes. While the temperature reduction was equal across the different time frames, the thermal load reductions vary over the different modeled periods because flow entering the HCC is variable throughout the year. For example, doubling the inflow while applying a constant temperature reduction results in a doubling of the thermal load reduction. The inflow thermal load reduction was summarized as an average per day over the various time frames by:

$$Thermal\ Load\ (\frac{bkcal}{day}) = \left(Q\frac{cf}{sec} * \Delta T(°\mathrm{C}) * \frac{28.317kg}{cf} * \frac{86400sec}{day} * \frac{1kcal}{\frac{kg}{1}°\mathrm{C}} \right) /1{,}000{,}000{,}000$$

Where:

- Thermal load = The average daily thermal load in bkcal/day over the time frame
- Q = The average of measured Snake River at Weiser flow (cfs) over the time frame
- ΔT = The temperature reduction (i.e., 2°C) per day over the time frame

In both the 1992 and 2002 model results, inflow water from the September through October and August through October time periods had a significant impact on the inflow thermal load reduction realized at the outflow before those impacts leveled off. In the 1992 model results (Table 7.1-1), 39% of the September through October inflow thermal load reductions were realized at the outflow, 47% of the August through October inflow thermal load reductions were realized at the outflow (an additional 8%), 52% of the July through October inflow thermal load reductions were realized at the outflow (an additional 5%), and 53% of the April through October inflow thermal load reductions were realized at the outflow—meaning that those 3 additional months combined (April, May, June) only resulted in an additional 1% of thermal benefit realization at the outflow. Similarly, in the 2002 model results (Table 7.1-2), 37% of the September through October inflow thermal load reductions were realized at the outflow, 43% of the August through October inflow thermal load reductions were realized at the outflow (an additional 6%), and 44% of the July through October inflow thermal load reductions were realized at the outflow—meaning that the magnitude of adding the thermal benefit from July was relatively smaller than the magnitude from August, September, and October.

Table 7.1-1.
1992 CE-QUAL-W2 modeled reductions in the HCC outflow 7DAM from a series of HCC inflow thermal load reductions over 4 time frames

Inflow reduction time frame	Inflow thermal load reduction[1] (bkcal/day)	Outflow 7DAM temperature reduction on Oct. 29 (°C)	Outflow thermal load reduction on Oct. 29[2] (bkcal)	% inflow thermal load reduction realized at the outflow
Sept. 1–Oct. 29	38	0.66	15	39
Aug. 1–Oct. 29	34	0.71	16	47
July 1–Oct. 29	33	0.75	17	52
April 1–Oct. 29	34	0.79	18	53

[1]Based on a 2°C equal per-day reduction and average flow over the time frame
[2]Based on daily average outflow cfs on Oct. 29

Table 7.1-2.
2002 CE-QUAL-W2 modeled reductions in the HCC outflow 7DAM from a series of HCC inflow thermal load reductions over 4 time frames

Inflow reduction time frame1	Inflow thermal load reduction[1] (bkcal/day)	Outflow 7DAM temperature reduction on Oct 29 (°C)	Outflow thermal load reduction on Oct 29[2] (bkcal)	% inflow thermal load reduction realized at the outflow
Sept. 1–Oct. 29	51	0.86	19	37
Aug. 1–Oct. 29	47	0.90	20	43
July 1–Oct. 29	45	0.91	20	44
April 1–Oct. 29	53	0.96	22	42

[1]Based on a 2°C equal per-day reduction and average flow over the time frame
[2]Based on daily average outflow cfs on Oct. 29

Both 1992 and 2002 showed a similar pattern: the results from the series of different time periods showed that each additional month with a reduced inflow thermal load, from the summer months through October, resulted in additional thermal load reductions realized at the outflow of HCD during the salmonid spawning period. In the 1992 model, this trend continued through the July through October time period before leveling off. In the 2002 model, this trend continued through the August through October time period before leveling off. While both model years clearly indicate the potential for April, May, and June inflow thermal load reductions to result in reductions of outflow thermal load during the salmonid spawning period, the magnitude of the thermal benefits realized from these months is comparatively small. Therefore, in the interest of conservatism, IPC proposes to exclude this April through June time period from the thermal benefit aggregation time period.

Because the 1992 and 2002 CE-QUAL-W2 reservoir model results identified different points at which this trend showed a plateau—July versus August—additional qualitative information was also used in the selection of the July through October 29 aggregate thermal benefit time period (as discussed in Section 7.1.2.1.3. Step Three—Thermal Benefit Aggregation and Aggregation Time Period). This information includes: 1) CE-QUAL-W2 modeled age of water within the HCC, 2) SR–HC TMDL discussion of retention time through the HCC, and 3) retention and release dynamics of water that entered the HCC during various times of the year.

First, the CE-QUAL-W2 modeled age of water within the HCC aligns with a July through October time period. Modeled water age within the HCC, represented as the month of the year when the water entered the model grid, shows that as the salmonid spawning period approaches, there are layers of water stored that entered the HCC from February through October. During the beginning of the salmonid spawning period, the mixing and release dynamics of theses layers of water will be variable each year depending primarily on flow, meteorological conditions, and operational conditions. In a low water year, water representing July through October is present and being mixed within and out of the reservoir (Figure 7.1-5). Qualitatively, water that entered the reservoirs during July through October is present in the reservoirs and has an influence on the release temperature during the salmonid spawning period.

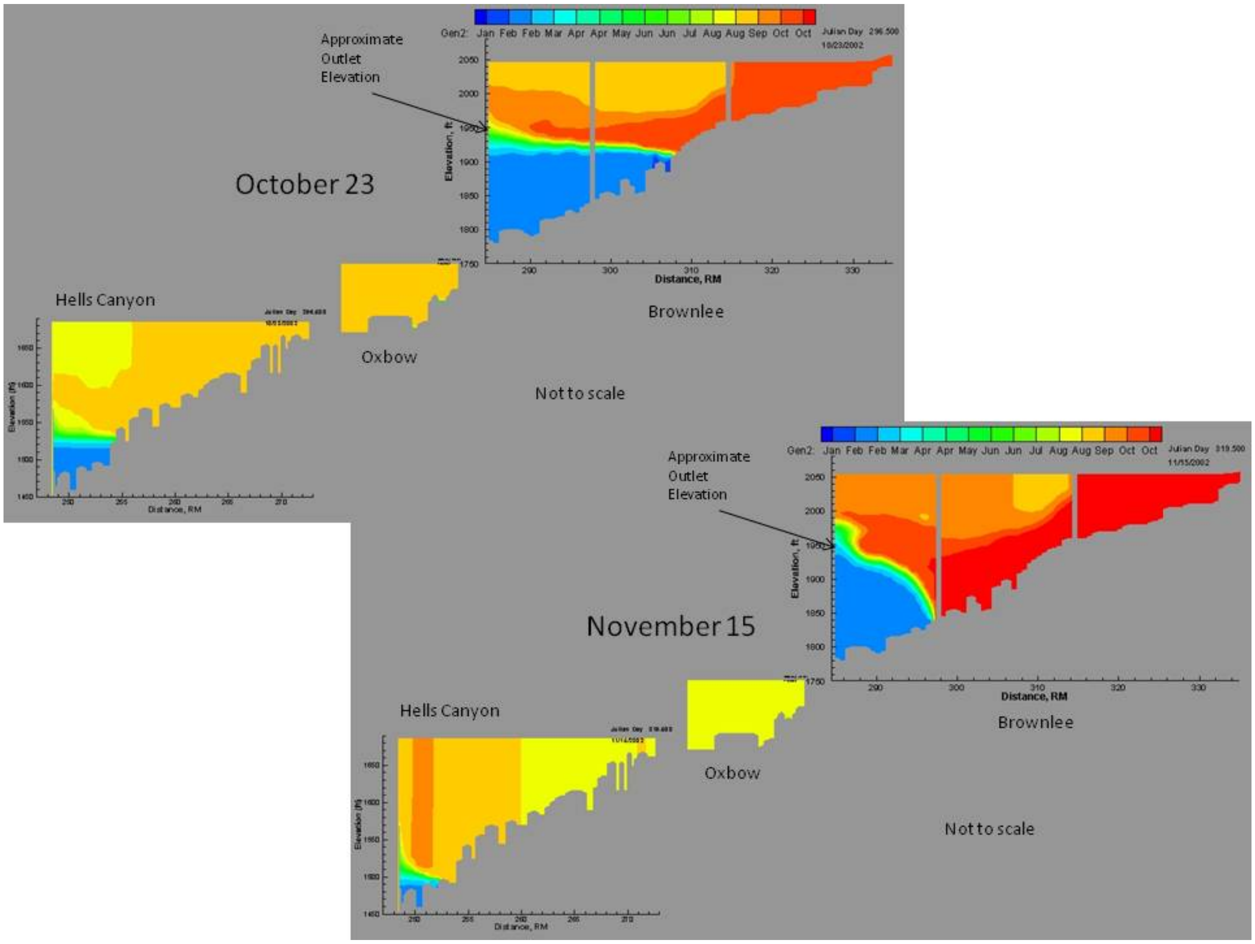


Figure 7.1-5
2002 CE-QUAL-W2 modeled water age within Brownlee, Oxbow, and Hells Canyon reservoirs represented as the month when water entered the model grid. Top panel shows conditions on October 23, and the bottom panel shows November 15.

Second, as discussed in Section 7.1.2.1.3. Step Three—Thermal Benefit Aggregation and Aggregation Time Period, the SR–HC TMDL notes that water may reside in the HCC for over 4 months, or just a number of days, and water that enters the HCC may stratify over time. The summer period, including July, was also identified in the SR–HC TMDL as a critical period for temperature loading upstream of the HCC. Third, as discussed in Section 7.1.2.1.3, the selection of July 1 through October 29 as the aggregate thermal benefit period is consistent with the complicated and delayed storage, retention, and release dynamic in the HCC.

7.1.2.1.4.2.2 Reservoir Attenuation

The same results from the 1992 and 2002 CE-QUAL-W2 reservoir model runs informed the selection of 50% as a HCC reservoir attenuation factor. This factor must be set so as to account for the loss of thermal benefits from upstream projects due to attenuation through the HCC reservoirs. Focusing on the July through October time period selected for thermal benefit aggregation shows that in the 1992 model, 52% of the average daily inflow thermal load reduction was realized at the HCC outflow during the beginning of the salmonid spawning period, while 44% was realized in the 2002 model (tables 7.1-1 and 2). In other words, these model runs demonstrate that approximately half (48–56%) of thermal benefits associated with the July through October inflows are not expressed at the outflow. Variability among model run results between years makes it problematic to definitively identify one single, precise attenuation factor for the HCC. Selecting a single number that implies precision to a level greater than 40% or 50% would misrepresent the inherent variability of the reservoir attenuation. Given these factors and the complex nature of the HCC, a 50% in-reservoir attenuation rate was selected to capture the thermal benefit attenuation through the system.

When selecting this rate, the presence of a margin of safety factor is relevant. The SR-HC includes a 10% margin of safety factor to be used in calculating IPC's thermal load exceedance (TMDL at 469–470). Because this margin of safety has already been accounted for in calculating the size of IPC's cumulative thermal load exceedance, selection of a reservoir attenuation rate on the lower end of this range is appropriate. A 50% in-reservoir attenuation factor is reasonably within the range identified by the 1992 and 2002 CE-QUAL-W2 reservoir model runs and captures the loss of thermal benefits through the HCC.

7.1.2.1.4.3. In-River Attenuation Factors

In addition to thermal benefit attenuation through the HCC reservoirs, attenuation of thermal benefits will also occur as water travels from SRSP project locations in the mainstem Snake River and tributaries to the HCC inflow. As discussed in Section 7.1.2.1.2. Step Two—River Attenuation of Upstream SRSP Thermal Benefits, due to the diversity of project locations and the complexity and variability involved in tracking individual quantities of water through riverine reaches between project locations and the HCC, IPC is proposing to use one attenuation factor for tributary projects (i.e., 25%) and a separate factor for in-river projects (i.e., 22%). IPC reviewed a collection of relevant existing modeling to inform the selection of these 2 attenuation factors. The primary piece of information utilized was Berger et al. (2009), which was developed as an evaluation of a previous (2009) IPC watershed program concept.

Berger et al. (2009) presented 4 scenarios where thermal load reductions from example projects were determined at the project site, then tracked through a Boise River model and a Snake River model from the Boise River confluence to Brownlee inflow. The loss or reduction of the project site thermal load reduction was determined and referred to as attenuation. Two of the Boise River scenarios were run with a 2001 model representing low water conditions and 2 with a 1999 model representing higher water conditions. The models were developed for the summer period, generally July through September. Based on these 4 scenarios, the range of thermal benefit attenuation through the Boise River (i.e., tributary attenuation) was 19 to 33 percent. In addition to these scenarios, project benefits from 2 scenarios were applied to the mainstem Snake River model, resulting in a range of 22 to 25 percent attenuation (Table 7.1-3). Considering the range of tributary attenuation results presented in Berger et al. (2009), the selection and proposal of 25% for the offset framework tributary attenuation factor is reasonable and within range.

Table 7.1-3.
Summary of model results presented in Berger et al. (2009) relative to attenuation of watershed project thermal benefit as water flows through the lower Boise River and mainstem Snake River from the mouth of the Boise River to Brownlee Inflow. Scenarios in 2001 represent low water conditions, while 1999 represents higher water conditions.

Model Year	Watershed Project Cooling Scenario	Boise River Thermal Benefit Attenuation (%)	Snake River Thermal Benefit Attenuation (%)
1999	1°C cooling from restoration near Middleton	23	25
2001	1°C cooling from restoration near Middleton	33	22
1999	0.5°C cooling of flow through Willow Creek Wetland	19	NA
2001	0.5°C cooling of flow through Willow Creek Wetland	27	NA

Note: NA indicates the modeling was not presented in Berger et al. (2009)

IPC's 1995 Snake River CE-QUAL-W2 model was also considered in the selection of the mainstem Snake River attenuation factor. A thermal load reduction was applied to the model near the Owyhee River confluence (RM 393) and tracked downstream to Brownlee Reservoir inflow (RM 340). This modeling was conducted over the August through October time period, which was the focus of the analysis at that time. The results showed that thermal processes and influences from tributaries as water moved downstream resulted in 22% of this thermal benefit being lost, or attenuated, by the time it reached Brownlee inflow. This result agrees well with the range of 22 to 25% presented by Berger et al. (2009). Therefore, considering both the mainstem Snake River results from Berger et al. (2009) and previously developed IPC modeling, the selection of 22% for the offset framework mainstem Snake River attenuation factor is also appropriate and within range.

7.1.2.2. Compliance with Salmon and Steelhead Migration and Cold-Water Aquatic Life Standards

The Idaho temperature criteria for the protection of cold-water aquatic life are a daily maximum temperature not to exceed 22°C, with a maximum daily average temperature of no greater than 19°C (IDAPA 58.01.02.250.02.b). The Oregon migration corridor requirement for salmon and steelhead includes a numeric 20°C 7DAM criterion that applies to the river downstream of HCD (OAR 340-041-0028(4)(d)). In addition to the numeric component, this OAR provision establishes narrative requirements that cold-water refugia are sufficiently distributed throughout a river to allow for salmon and steelhead migration without significant adverse effects from higher water temperatures in the river, and a seasonal thermal pattern in the Snake and Columbia rivers that reflects the NSTP.

The SR–HC TMDL did not give HCC a load allocation for the salmonid rearing/cold-water aquatic life standard based on available data and modeling work completed by IPC that showed if the water flowing into Brownlee Reservoir was at or below numeric temperature targets for salmonid rearing/cold-water aquatic life, water leaving the HCC at HCD would also be below the numeric temperature targets. The DEQs found the HCC is not the source of the heat load in the reservoirs and that if upstream conditions were cooler, the water exiting the HCC would also be cooler. Based on those findings, the DEQs concluded that the HCC is not "contributing to temperature exceedances specific to the salmonid rearing/cold water aquatic life designated use and no requirement for temperature adjustment, specific to salmonid rearing/cold water aquatic life use" was assigned to the HCC" (TMDL, at 404–405, 465). Since the SR–HC TMDL analysis was conducted using Oregon's previous 17.8°C criterion, IPC presents a similar analysis here relative to the current criteria (i.e., the Idaho 19°C daily average and Oregon 20°C 7DAM) that supports the conclusion in the SR–HC TMDL that continued operations of the HCC following relicensing will not cause or contribute to a violation of either the 19°C Idaho or the 20°C Oregon numeric criteria (see Section 7.1.2.2.1. Compliance with Numeric Criteria).

The purpose of each of the narrative criteria, sufficiently distributed cold-water refugia, and reflection of the NSTP is to protect fish from excessive temperatures during the migration period. For the reasons set forth below (and discussed in Section 6.1.2.3.1. Salmon and Steelhead Migration and Cold-Water Aquatic Life), IPC submits that the HCC currently complies with each of these narrative criteria and that the implementation of the SRSP, a large-scale upstream watershed restoration program, will only further protect fish from excessive temperatures, thus providing further assurances of that compliance.

7.1.2.2.1. Compliance with Numeric Criteria

As discussed in Section 6.1.2.3.1. Salmon and Steelhead Migration and Cold-Water Aquatic Life, the DEQs concluded in the SR–HC TMDL that the HCC is not responsible for elevated Hells Canyon temperatures in the summer months relative to the numeric criteria at the time, 17.8°C. That conclusion was supported at the time with an analysis of measured temperature data and the results of IPC temperature modeling that demonstrated that if inflows were at or below the numeric temperature criteria, the outflow at HCD would also be at or below the numeric temperature criteria for cold-water aquatic life and salmonid migration. (SR–HC TMDL at 381; 402–04). The following analysis and information uses HCC CE-QUAL models to model the resulting outflow temperature conditions if inflow temperature met numeric criteria to reevaluate the SR–HC TMDL conclusions relative to current criteria.

To be consistent with the approach in the SR–HC TMDL, the first step in the analysis is to determine which of numeric criteria are the most stringent (i.e., would result in a lower temperature). The SR–HC TMDL evaluation of Oregon and Idaho water-quality standards, as first published in 2003, identified the then-existing Oregon numeric temperature criterion for salmonid rearing as the most stringent criterion. That criterion provided for a 7DAM temperature of 17.8°C (IDEQ and ODEQ 2004). Therefore, the SR–HC TMDL applied this criterion for the year-round inflows to the HCC reservoirs and the outflows from HCD from June to September. Oregon has since revised its water-quality standards, including temperature standards. The EPA has approved these revisions. For aquatic life and salmonid rearing, Oregon currently has 2 temperature criteria applicable to waters of the HCC and Snake River:

- The 7DAM temperature of a stream identified as having Lahontan cutthroat trout or redband trout use may not exceed 20°C (OAR 340-041-0028(4)(e)). This criterion is applicable to the HCC reservoirs and Snake River from RM 247.5 to RM 409 (i.e., HCC inflows).

- The 7DAM temperature of a stream identified as having a migration corridor use for salmon and steelhead may not exceed 20°C (OAR 340-041 -028(4)(d)). This criterion is applicable to the Snake River from RM 169 to RM 247.5 (i.e., HCC outflow).

Idaho temperature criteria for the protection of cold-water aquatic life are a daily maximum temperature not to exceed 22°C, with a maximum daily average temperature of no greater than 19°C (IDAPA 58.01.02.250.02.b).

Daily average, daily maximum, and 7DAM statistics were calculated from temperature measurements made every 10 minutes during 2002, along with the reduction needed to lower the peak 7DAM value to the revised Oregon criteria (i.e., 20°C). The needed reduction to meet the 7DAM was then subtracted from the daily average, daily maximum, and 7DAM to calculate reduced temperature statistics (Table 7.1-4). Comparing the reduced temperature to the various criteria showed that if the temperature was reduced sufficiently to meet Oregon’s revised 7DAM criteria, Idaho’s daily maximum (i.e., 22°C) would also be met; however, Idaho’s daily average criteria of 19°C would still be exceeded (Table 7.1-4, Figure 7.1-6). Based on this analysis, the conclusion is that Idaho’s 19°C daily average criteria is the most stringent of the current applicable criteria for the Snake River at the inflow to Brownlee Reservoir and HCD outflow during the aquatic life and salmonid rearing period.

Table 7.1-4
Snake River Brownlee Reservoir inflow and HCD outflow daily temperature statistics in 2002 (baseline) and reduced by the amount needed to meet Oregon’s 7DAM criteria (reduced)

	Baseline				Reduced		
Location	**Maximum Daily Average (°C)**	**Maximum Daily Max (°C)**	**Maximum 7DAM (°C)**	**Reduction needed (°C)**	**Maximum Daily Average (°C)**	**Maximum Daily Max (°C)**	**Maximum 7DAM (°C)**
Inflow	28.1	28.8	28.1	8.1	20.0	20.7	20.0
Outflow	21.3	21.5	21.3	1.3	20.0	20.2	20.0

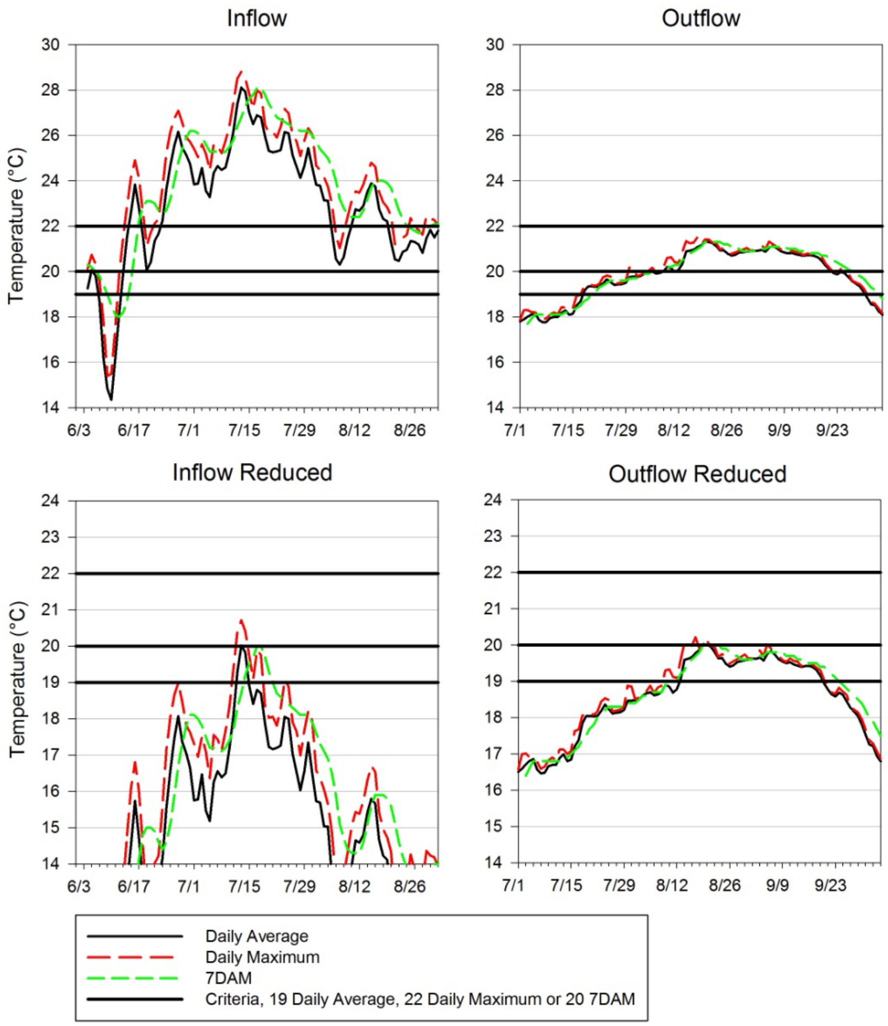


Figure 7.1-6
Snake River Brownlee Reservoir inflow and HCD outflow daily temperature statistics in 2002 compared with applicable Oregon (i.e., 20°C 7DAM) and Idaho (i.e., not to exceed 22°C daily maximum and 19°C daily average) temperature criteria. Figures with reduced temperatures show all the daily statistics reduced by the amount needed to meet the 20°C 7DAM criteria.

The next step in the analysis is to reduce Brownlee inflow temperature so that the Idaho 19°C daily average criterion is met. The SR–HC TMDL did not describe specifically how the inflow temperature was reduced or what the “shape” of the inflow thermal regime was after the reductions. The analysis presented here uses 3 assumptions to develop 3 separate inflow temperature conditions that all meet the numeric criteria. While there are potentially limitless assumptions and iterations that can be used in the development of these temperature conditions, the objective of this analysis is to develop 3 conditions that cover a wide range of assumptions and results. Below, the 3 assumptions and resulting conditions are compared and contrasted with measured temperatures to illustrate the technical defensibility of each.

Of the 3 temperature conditions, the first temperature condition is the most basic and simply caps the daily average inflow temperature at 19°C (Capped, Figure 7.1-7). This temperature condition is not reflective of a natural river condition but it is a straightforward way to represent an inflow condition that meets the numeric criteria. The second temperature condition is developed by calculating the percent reduction needed at the summer peak to meet the numeric criteria. This percentage reduction is then applied year-round. Since it is a percent reduction, it results in relatively large degree reductions when temperature is warm and small degree reductions during cold times of the year (% Year-Round, Figure 7.1-7). This temperature condition is reflective of a natural river condition as it essentially shifts the baseline condition down proportionally. The third temperature condition applies the same percent reduction in tapered fashion. That is, the entire percent reduction is applied at the peak; however, the percent reduction is tapered off to zero at the beginning and end of the year. This condition also reflects a natural river condition since it also shifts the baseline condition down proportionally while recognizing the potential for less temperature sensitivity in the winter, spring, and fall seasons (% Tapered, Figure 7.1-7). Of the 3 temperature conditions, both the % Year-Round and % Tapered conditions are reflective of a natural river condition and, more specifically, the % Tapered condition is comparable with measured temperature in the Snake River upstream of the HCC (i.e., below Bliss Dam and upstream of American Falls Reservoir at Blackfoot, Figure 7.1-8).

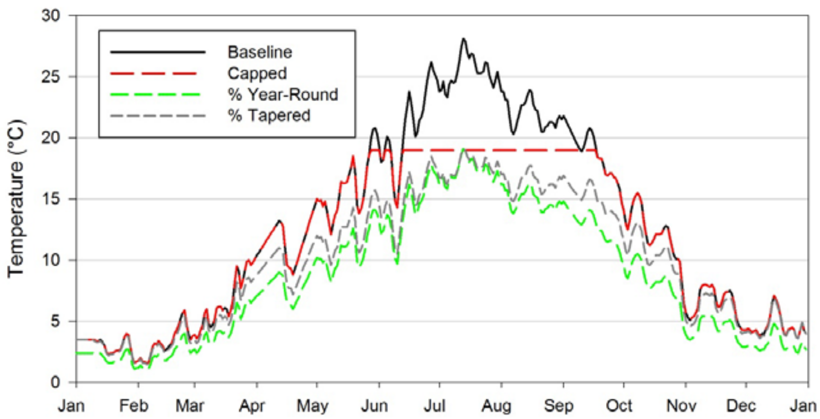


Figure 7.1-7.
2002 Baseline CE-QUAL-W2 daily average temperature inflow conditions compared with 3 separate inflow conditions that meet the numeric criteria of a daily average not to exceed 19°C

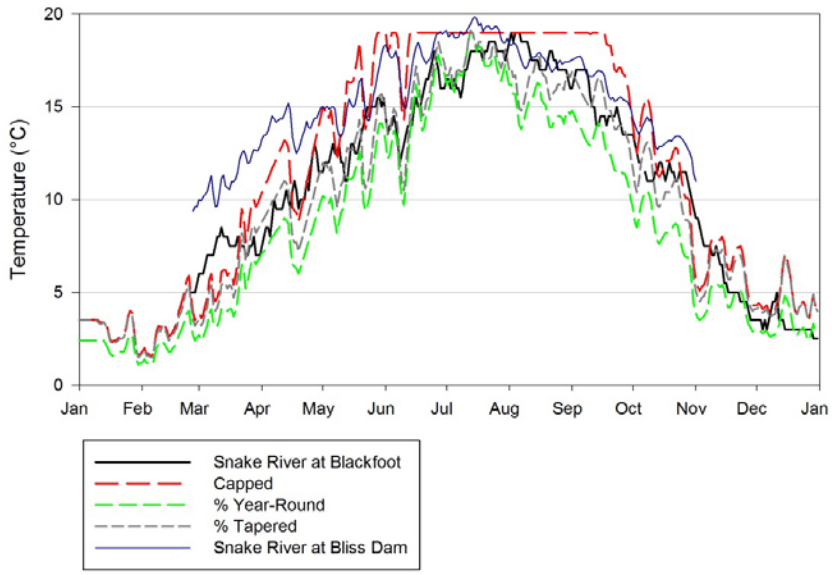


Figure 7.1-8.
2002 inflow conditions that meet the numeric criteria of a daily average not to exceed 19°C compared with temperature measured at 2 locations in the Snake River, at Bliss Dam (RM 560) in 2002, and near Blackfoot, Idaho, above American Falls Reservoir in 2005 (another low-water year).

The Capped, % Year-Round, and % Tapered inflow temperature conditions were modeled through the 2002 HCC CE-QUAL-W2 model applications (see Section 7.1.2.1.4.1. Model Background for model background information) and resulting summer outflow temperature compared with criteria. The % Year-Round inflow condition meeting the Idaho 19°C daily average criterion resulted in HCC outflow also meeting the same temperature criterion (Figure 7.1-9). The HCC outflow results from the % Tapered condition also met the Idaho 19°C criteria on all days but one where modeled temperature deviated by only 0.2°C. Both the % Year-Round and % Tapered inflow condition meeting the Idaho 19°C daily average criterion resulted in HCC outflow meeting Oregon's 20°C 7DAM criterion (Figure 7.1-10). These model results reevaluate the modeling analysis referred to in the SR–HC TMDL and support the conclusion that if inflow temperature conditions met the current most stringent numeric criteria, the HCC outflow temperature would also meet all applicable numeric criteria. To expand on that conclusion, the general type of inflow temperature condition that resulted in outflow meeting numeric criteria represented a natural river condition and not an artificial "capped" regime.

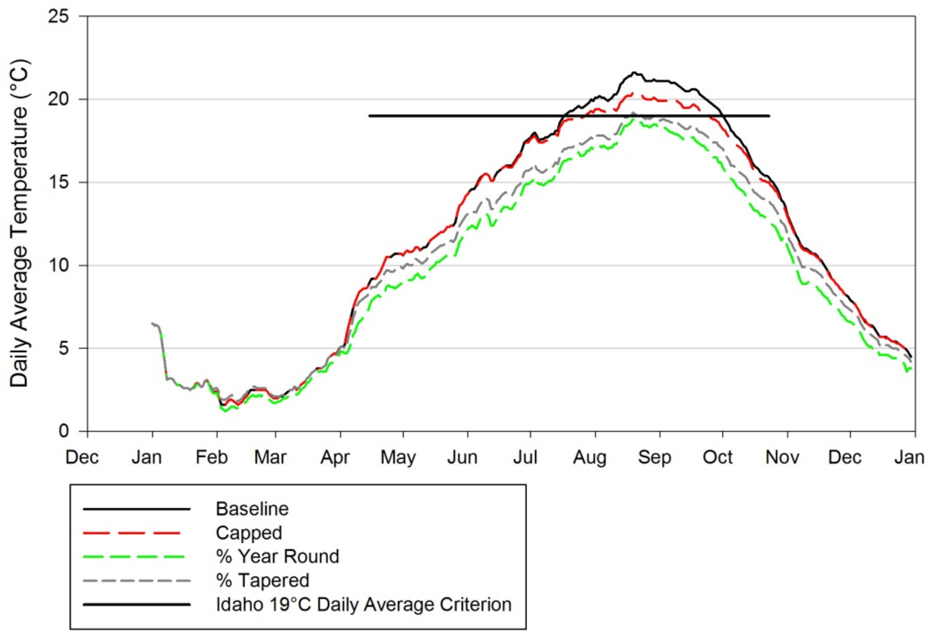


Figure 7.1-9
Modeled daily average 2002 CE-QUAL-W2 HCC outflow temperature under baseline (i.e., calibrated) and 3 inflow temperature conditions that all met the Idaho 19°C daily average criterion (Capped, % Year Round, and % Tapered).

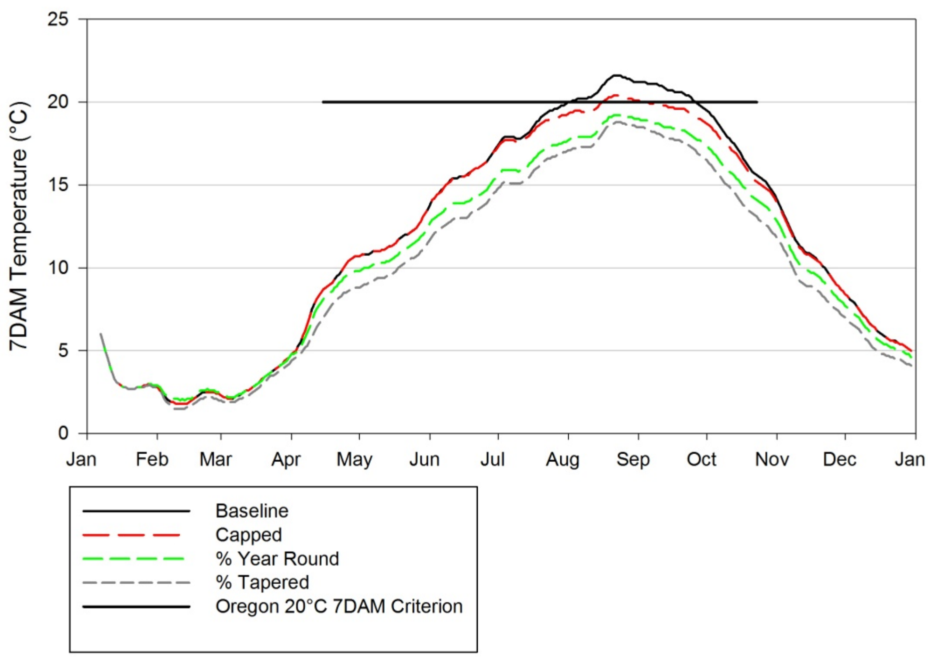


Figure 7.1-10
Modeled 7DAM 2002 CE-QUAL-W2 HCC outflow temperature under baseline (i.e., calibrated) and 3 inflow temperature conditions that all met the most stringent Idaho 19°C daily average criterion (Capped, % Year Round, and % Tapered).

7.1.2.2.2. Compliance with Cold-Water Refugia

The first of the 2 narrative criteria provides that the water bodies “must have coldwater refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body.” As referenced in Section 6.1.2.3.1.1 of this application, the DEQs concluded in the SR–HC TMDL that, both within and downstream of the HCC, the designated beneficial uses, which include salmon and steelhead migration, are being supported through availability of cold-water refugia” (SR–HC TMDL, at 422). This conclusion was supported by the referenced population study (Chandler et al. 2003). The potential ecological benefit of tributaries providing thermal habitats for organisms in downstream waters is also documented in the scientific literature and bolstered by a recent scientific study finding of the importance of perennial and ephemeral streams in providing cold-water refugia (Ebersole et al. 2015; Fullerton et al. 2015). The river downstream of Hells Canyon dam has 132 perennial streams and 813 intermittent streams distributed throughout its length that provide cold-water thermal refuge to varying extents (See Exhibit 6.1-2). Ebersole et al. (2015) conservatively defined cold-water patches as discrete areas of relatively cold water that were ≥3°C colder than the ambient stream temperature. While not a complete data set of all perennial streams, temperature data of surface flows collected by IPC during 2003 and 2004 show that during the critical summer months of July through September, the majority of the perennial streams measured would provide refugia (Exhibit 6.1-2). These measurements do not include the potential additional benefit of subsurface flow upwelling into the Snake River at these stream mouths. In addition, the free flowing river retains natural processes that create areas of downwelling and upwelling of surface flows into the hyporheic zone of the riverbed, which can also create thermal refugia in areas of upwelling. Based on the current presence of thermal refugia, along with the expected thermal benefits of the proposed SRSP, compliance with the cold-water thermal refugia requirements is assured.

7.1.2.2.3. Compliance with NSTP

The second narrative criterion associated with the migration corridor provides that “the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern.” The concept of preserving or restoring natural temperature patterns was first addressed in the EPA Region 10 2003 guidance for state water-temperature standards. In waters with a designated use of salmon and trout migration corridors, the guidance called for a standard of 20°C and a requirement to “protect and, *where feasible* restore the natural thermal regime” (emphasis added), and indicated the objective of thermal regime restoration is some approximation of the natural watershed as it existed before human alteration of the landscape.

Oregon water-quality standards do not define NSTP. ODEQ has interpreted the intent of NSTP standard to be “to protect migrating fish from temperatures routinely exceeding the 20°C criterion. Attainment of NSTP would allow the migrating fish to experience varying temperatures, not constant warm temperature.” (ODEQ Memo 2011). In IPC’s view, the NSTP criterion is intended to work in conjunction with the cold-water refugia criterion to “allow salmon and steelhead migration without significant adverse effects” from peak 20° C or greater temperatures during migration. (OAR 340-041-0028(4)(d)). The presence of cold water thermal refugia downstream of HCD reduces the potential for adverse effects on migrating fish. As detailed and shown in Section 6.1.2.3. Outflow Temperature, the HCC is not creating conditions whereby migrating fish are being exposed to "constant warm temperature," nor substantially extended periods of temperatures in excess of 20°C.

The EPA temperature guidance indicates it may be necessary to supplement the numeric criterion with a narrative provision like NSTP to address the concern "that rivers with significant hydrologic alterations (e.g., rivers with dams and reservoirs, water withdrawals, and/or significant river channelization) may experience a loss of temperature diversity in the river, such that maximum temperatures occur for an extended period of time and there is little cold water refugia available for fish to escape maximum temperatures." The HCC does not cause a condition where "maximum temperatures occur for an extended period of time." In fact, the potentially harmful maximum temperatures measured in the inflowing water to Brownlee Reservoir are not found in water flowing from HCD because of the cooling effect of the HCC when inflows exceed 20°C.

IPC's proposed SRSP complements the summer cooling effects of the HCC and will therefore provide assurance of compliance with the NSTP narrative criterion. A river's thermal regime encompasses both the temporal and spatial variability in water temperature. In-stream structural diversity, channel complexity, and healthy riparian zones promote the formation and maintenance of thermal diversity (Poole and Berman 2001). Actions that provide a source of wood (such as riparian re-vegetation) and management practices that leave wood in-stream can increase thermal patchiness through increased hyporheic exchange (Sawyer et al. 2012).

In the SR–HC TMDL, based on modeling reviewed at the time the DEQs concluded that if upstream conditions were cooler, the water exiting the HCC would also be cooler (SR–HC TMDL, at 405). Figure 7.1-10 further illustrates how outflow temperatures could be expected to change under modeled reduced inflow temperature scenarios. Section 7.1.2.2.1. Compliance with Numeric Criteria describes how IPC modified inflowing temperatures to a maximum summer temperature of 19°C using 3 alternative thermal regime shapes. The SRSP will likely not result in thermal regimes represented by the modeled hypothetical regimes (e.g., temperature reduction to 19°C). Rather, the modeling is presented to illustrate that as upstream thermal loads are reduced, this reduction is translated through the HCC and outflow temperatures are reduced.

Qualitatively, Figure 7.1-10 shows that inflowing water temperature reductions can be expected to result in accelerated late summer and fall cooling compared to what is currently occurring in the HCC outflows, which supports the conclusion on the SR–HC TMDL that if upstream temperatures are cooler, the water exiting the HCC will also be cooler.

7.1.2.3. The SRSP

A large collection of data and information has been developed and analyzed through the course of IPC's work with TFT. The following discussion in this section summarizes the key details of this work, including the program area; eligible restoration actions for thermal benefits; methods for quantification of thermal benefits from those actions; total estimated supply of thermal benefits in the project area; implementation considerations; ongoing milestones, actions, tracking, and monitoring; and adaptive management and reporting. This section outlines IPC's proposal for the SRSP and is intended to be a summary of Exhibit 7.1-1, where substantially more detail on the SRSP is provided by TFT.

7.1.2.3.1. SRSP Program Area

Thermal benefits will be generated from SRSP projects located on the mainstem Snake River and its tributaries from HCD upstream to Swan Falls Dam. The eligible tributaries or subbasins include but are not limited to, the following: Boise River, Brownlee Reservoir creeks, Burnt River, Malheur River, Middle Snake–Payette River, Owyhee River, Payette River, Pine Creek, Powder River, Succor Creek, and Weiser River. The thermal benefit modeling and area eligible for projects does not extend upstream beyond any reservoir or substantial impoundment.

7.1.2.3.2. Proposed Restoration Actions for Thermal Benefits

There are 3 actions currently prioritized for generating thermal benefits. These actions are listed below along with a description of how thermal benefits from these actions can currently be quantified. The currently quantifiable thermal benefits represent only a portion of the overall anticipated benefits from these projects.

- In-stream habitat restoration projects in the mainstem Snake River that would reduce surface-area exposure to thermal loading from the sun and may provide a small amount of additional shade from plantings:
    - Island enhancement projects
    - Island creation projects
    - Inset floodplain creation
    - Emergent wetland creation
- Riparian revegetation projects in tributaries of the Snake River that would produce shade and block thermal loading from the sun.
- In-stream flow augmentation activities in tributaries of the Snake River that would increase depths and velocities and reduce water temperature. While literature and studies indicate increased flow in the tributaries will result in improved temperature conditions in the tributaries, the methods to calculate and include the thermal benefits are still under development. Until thermal benefits from in-stream flow augmentation can be included, benefits from this action will not be applied toward meeting the HCC outflow thermal load exceedance.

The above 3 actions are the primary categories of measures that SRSP will focus on for thermal benefits. However, as lessons are learned through implementation, or thermal benefit quantification methods improve or change, it may be appropriate to include additional or substitute restoration actions in the SRSP portfolio. For example, sediment-reduction actions are currently planned as project stewardship actions necessary to protect the in-stream habitat projects (see Section 7.1.2.3.6. and Exhibit 7.1-1), but no quantified thermal benefits from these actions would be claimed at this time. However, through the sediment-reduction action, there is the potential for warm water returns to the mainstem Snake River to be reduced or eliminated. The dynamics of surface and subsurface agricultural return water are known to be complex, and overall thermal benefits may be difficult to quantify; however, this potential still serves as an example of additional actions that may be determined to have quantifiable thermal benefits in the future. If new or additional restoration actions are identified that provide quantifiable thermal benefits, IPC may incorporate these actions into the SRSP after appropriate review and approval from the DEQs, and as required by FERC.

7.1.2.3.3. Thermal Benefit Quantification Methods

There are 3 models or methods available for quantifying thermal benefits from the various project types: 1) Shade-A-Lator for riparian revegetation and revegetation components of the in-stream projects, 2) wetland energy budget models for emergent wetlands, and 3) a suite of currently available models for surface-area changes associated with island projects.
These models have certain limitations, and consequently there are challenges associated with capturing and quantifying all of the thermal benefits that may be realized from these projects. Primarily, this is because the current models are limited to the quantification of potential reduced thermal loading from the sun. Many other benefits, such as increased thermal buffering and cold-water refugia and increased floodwater storage (i.e., bank storage), are not captured by the current models (Exhibit 7.1-1). Because of these limitations, the thermal benefits of the restoration actions planned for the SRSP implementation calculated with these methods are currently undervalued. In other words, the modeled thermal benefit assigned to each project derived from these methods likely does not represent the full thermal benefit of the project. IPC's proposal relies on the currently available methods but allows for improvements and the quantification of additional thermal benefits in the future as appropriate methods are developed and approved by the DEQs, and as required, by FERC.

The modeled thermal benefits for each project will be determined and documented in the project planning and design phase. Once the project is completed, the modeled thermal benefits of the project will be aggregated for the July through October 29 period, then will be counted in conjunction with other projects to offset the HCC outflow cumulative thermal load exceedance. As long as the project continues to be maintained and functions in accordance with the project specifications, as confirmed by the monitoring and tracking components of the SRSP and independent performance audits, the initially determined thermal benefits will remain applicable towards the offset. This proposed procedure is described in more detail in Section 7.1.2.3.5.

7.1.2.3.4. SRSP Implementation Considerations

IPC and TFT have conducted an in-depth analysis and discussion relative to the implementation of the SRSP to ensure the SRSP is achievable and feasible from a thermal benefit supply (i.e., project availability), project design and implementation (e.g., permitting, quality standards, construction, and supply chain), and regulatory standpoint. IPC is proposing to implement the SRSP consistent with the framework and guidelines presented in Exhibit 7.1-1, and IPC expects to refine and further develop this information in the future with TFT and the DEQs.

7.1.2.3.4.1. Thermal Benefit Supply and Feasibility

TFT evaluated the total thermal benefit supply through a comprehensive landscape assessment to determine what areas have the potential for project implementation based on current conditions and what the potential thermal benefits from those individual projects would be. TFT found that approximately 15.216 bkcal/day (averaged from July–October) would be available from 55 potential in-stream projects, and about 14.939 bkcal/day (averaged from July–October) would be available from riparian revegetation projects. In total, TFT identified approximately 30.155 bkcal/day (averaged from July–October). TFT then applied ownership boundaries to the thermal benefits to better assess recruitment realities. The methodologies and assumptions used to develop these supply estimates are described in Exhibit 7.1-1. Even after reducing the aggregate amounts for tributary and in-river attenuation, 22 or 25%, respectively, and accounting for reasonable recruitment percentages, TFT determined there are sufficient potential projects and thermal benefit to reach the amount needed in the offset framework. The TFT recruitment feasibility analysis is based on prior experience implementing these types of watershed restoration actions in other basins in the Northwest. IPC and TFT expect that only a percentage (see Section 2.4. of Exhibit 7.1-1 for more details) of the potential projects will actually be feasible to implement depending on the willingness of landowners to participate in the program (i.e., recruitment). TFT also analyzed the timing of thermal-benefit implementation, concluding it will be necessary to build up supply chain and labor capacity for this geographically dispersed program. As a result, TFT identified suggested thermal benefit milestones over a 30-year implementation timeframe. IPC is proposing that the actual mix of project types for the SRSP will be based on project availability, feasibility, and thermal benefit-to-cost ratio, which will be adaptive over the life of the implementation period.

7.1.2.3.4.2. Project Design and Implementation

TFT, in consultation with IPC, developed draft restoration quality standards for each SRSP project type. These draft restoration quality standards are based on relevant literature, TFT experience, interviews with local professionals, and NRCS Conservation Practice Standards (see Attachment 1 of Exhibit 7.1-1). These draft restoration quality standards are specific to project type and will guide the selection, design, implementation, monitoring, and maintenance of SRSP projects over time. These quality standards will help ensure quality, integrity, and consistency over the term of the program. The draft restoration quality standards will be refined after 401 certification and before full program implementation begins.

Should the SRSP be approved by the DEQs as a component of the 401 certification, IPC intends to implement research projects prior to issuance of the FERC license to explore and further define the details of SRSP project implementation and to help refine the draft restoration quality standards. To the extent these research projects meet the criteria to apply to the offset of the HCC outflow cumulative thermal exceedance, IPC expects these benefits will be applied to the offset. These projects will also allow for more tangible information relative to the additional benefits that can be achieved through these projects. As an example, in 2014 IPC initiated the Bayha Island Research Project. IPC is currently assembling information relative to the design, development, and feasibility of this in-river habitat and thermal benefit project. Additional information continues to be obtained as the implementation of that project continues. Research projects relative to riparian restoration have not yet been initiated, but IPC is considering riparian research projects for future implementation.

7.1.2.3.4.3. Regulatory Considerations

The thermal benefits generated from SRSP project actions can be counted toward the cumulative thermal load exceedance so long as those thermal benefits are “additional.” A thermal benefit is considered additional when the thermal benefit or the restoration action from which the thermal benefit is realized is not already required by federal, state, tribal, or local law or regulation, and the restoration action would not have been generated without funds or resources provided by IPC. Additionality [35]and related regulatory considerations are addressed in greater detail in Section 2.5.2 of Exhibit 7.1 -1. As more specifically described in that Exhibit, no existing affirmative land-management obligations have been identified for SRSP project sites on private and non-federal public property in the SRSP program area that would require implementation of SRSP project actions, or reduce or otherwise affect the total thermal benefit calculated from potential SRSP project sites. As such, all of the thermal benefits generated from SRSP restoration actions should be credited toward IPC's cumulative thermal load exceedance. This conclusion is an integral component of the SRSP, and approval and incorporation of the SRSP in the 401 certification constitutes acceptance of the conclusion. As described in Section 2.5.2 of Exhibit 7.1-1, periodic verification of this conclusion, and adaptation if needed based on new laws and regulations, will occur at regular SRSP adaptive management intervals over the term of the SRSP. Beyond additionality considerations, IPC will receive confirmation from participating landowners that land-use operations at the property are understood to be in compliance with all applicable laws and regulations (see Attachment 1 of Exhibit 7.1-1).

7.1.2.3.5. Ongoing Milestones, Project Tracking, Monitoring, and Reporting

IPC's proposal for the SRSP includes an interrelated system of thermal benefit milestones, project stewardship (e.g., maintenance, discussed in Section 7.1.2.3.6. Project Stewardship), project monitoring, and project tracking. IPC's proposal specifically includes the following monitoring components (see Section 2.6.2 of Exhibit 7.1-1) to be developed in detail post-certification in consultation with the DEQs as part of the TMCP:

- Project monitoring will follow a 3-tiered approach:

    1. Rapid qualitative (i.e., project) monitoring at all sites

        - Goal is to ensure projects remain in place and are continuing to demonstrate progress toward forecasted conditions.
        - Repeat photo points and standardized site assessment checklist to allow for consistent data collection and assessment.
        - Conducted annually from implementation through "establishment," which is expected to be 5 to 10 years following implementation.
        - After establishment, qualitative monitoring will continue until the end of the license term at a gradually reduced frequency.

    2. Remote effectiveness monitoring at all sites

[35] Additionality means a thermal benefit is considered additional (and therefore eligible to count toward achievement of IPC's cumulative thermal load exceedance) when the thermal benefit or restoration action from which the thermal benefit is realized is not already required by federal, state, tribal or local law or regulation, and the restoration action would not have been generated without funds or resources provided by IPC.

- Goal of efficient tracking of thermal benefit progress of projects over a broad geographic area; provides continued backup that projects remain in place and are continuing to demonstrate progress toward forecasted conditions as qualitative monitoring frequency decreases at sites over time.
- LIDAR or other applicable remote sensing technologies repeated every 5 years over the life of the FERC license.

3. Quantitative (i.e., effectiveness) monitoring on a selected sample of projects representative of the in-stream habitat and riparian revegetation project types

    - Generate confidence that projects are tracking toward performance objectives and modeled conditions (e.g., % canopy cover for riparian projects or change in water velocity for in-stream projects).
    - Confirm modeling assumptions used in thermal benefit calculations are valid.
    - Use results to improve and adaptively manage the effectiveness of site implementation and maintenance for future projects.
    - Inform qualitative checklist questions so the checklist helps track projects consistently with trends observed at quantitative monitoring sites.

- The SRSP monitoring plan and approach will be adaptive and managed over the life of the FERC license.

- Independent verification and third-party auditing program.

    - Confirmation that every project has been initially implemented consistent with project design and implementation quality standards

    - Audit process on a selected subset of sites

        - Auditor will review monitoring results and records for the selected sites and perform site visits as necessary to determine if the sites are materially consistent with the records and the projects are indeed in place and functioning/progressing as designed/anticipated.

Results of the above monitoring components will provide feedback to the modeling, generation, accounting, tracking, and reporting of the thermal benefits applicable to the offset. IPC’s proposal for this process is captured by the following outline:

- Thermal benefits of projects are estimated during the project design phase.

- Projects are implemented according to design.

- Thermal benefits of projects are modeled after implementation has been completed.

- Implementation is verified to be consistent with project design and implementation quality standards. Once verified, project details will be made available through a tracking system (e.g., program website).

- Project thermal benefits are counted toward the overall offset.
- Projects are monitored and audited.
  - So long as projects are implemented and maintained in accordance with quality standards and pass program audits, the thermal benefits of these projects will count toward the offset.
  - If projects are not implemented or maintained in accordance with quality standards (in a way that materially affects the thermal benefits produced by the project) or fail program audits, the thermal benefits of these projects cannot be counted toward the offset until subsequent maintenance and monitoring show the project has returned to specifications, [36] at which time thermal benefits will be reapplied to the offset.
  - Information obtained from the quantitative monitoring will be used to inform the thermal benefit calculation, implementation, and maintenance of future projects but will not be used to adjust thermal benefits already modeled and counted toward the offset.
- Thermal benefit milestones.
  - Within 15 years of FERC license issuance, IPC proposes to have projects implemented and maintained according to project specifications equal to 50% of the applicable cumulative thermal load exceedance.
  - Within 30 years of FERC license issuance, IPC proposes to have projects implemented and maintained according to project specifications equal to 100% of the applicable cumulative thermal load exceedance.
  - These milestones will be reviewed during program adaptive management and agency review cycles and may be modified based on monitoring and implementation information.
- Life of thermal benefits.
  - IPC proposes to sign renewable land access and protection agreements with participating landowners to protect the longevity of thermal benefits.
- Annual reporting will include the following:
  - The results of the quantitative and qualitative monitoring, including a map showing the location of all projects implemented to date together with the thermal load reduction credits assigned to each project and the site-level monitoring reports.

[36] This process will include appropriate provisions for force majeure.

   - A description of the proposed projects scheduled for implementation in the next year or future years, including IPC's estimate of the projects' aggregate thermal load to be applied toward the offset.
   - A description of the projects implemented in that year, including the status of implementation, expected completion date, and any modeled or expected thermal benefits associated with the projects.
   - Audit review report, including a summary of whether the sites surveyed comported with the acceptance threshold for the audit and any remediation activities, if necessary.
   - A summary of the progress made toward achieving the offset amount, including IPC's assessment of whether the program is on track to achieve compliance with the 15- and 30-year compliance targets established by the 401 certification.
   - A summary of any adaptive management measures, amendments, or modifications to the TMCP or SRSP being considered or recommended. The summary shall include a discussion of any alternative or supplemental measures being considered, including issues related to the development of Plan B (see section 7.1.2.4.1.1. Plan B) and the status of any mercury or other water-quality studies or analysis related to either Plan B or another alternative or supplemental measure being considered.
- Five-year review statement, agency review cycle, and adaptive management steps. In addition to the annual reporting, a 5-year review statement will be submitted every fifth year following issuance of the FERC license. This will include all the elements of the annual report plus the following:
   - Evaluation of observed changes occurring relative to pre-project conditions in monitored implemented projects (including vegetation, hydrology, morphology).
   - A summary and evaluation of changes in applicable laws or regulations related to the regulatory baseline in the SRSP program area that may affect the crediting of project thermal benefits.
   - Changes to quality standards and implementation guidance and modeling of thermal benefits. This includes whether revision to thermal benefit modeling or accounting procedure for future projects are recommended.
   - Summary of thermal benefits associated with previously implemented projects that were not previously quantified, including any benefits unquantified due to a lack of data or recognized methodology.
   - Summary of new SRSP restoration actions and quantification methodologies proposed for the next cycle of the SRSP.

- A report and consolidation of the previous annual summaries of the progress toward achieving the offset amount, including an analysis and updated assessment of whether the program is on track to achieve compliance with the 15- and 30-year compliance targets established by the 401 certification. The report shall include a discussion of any alternative or supplemental measures (see Section 7.1.2.4.1. Alternative of Supplemental Measures to the TMCP) being considered together with the status of the development of a Plan B (see Section 7.1.2.4.1.1. Plan B) and any mercury or other water-quality studies or analysis related to Plan B.

7.1.2.3.6. Project Stewardship

IPC will actively maintain SRSP project sites to ensure the thermal benefit generating measures remain in place and functioning for the term of the renewed FERC license. These actions will be conducted in accord with quality standards for stewardship of the thermal benefit projects.
For the upland sediment reduction program, specific compliance requirements are not proposed beyond tracking and reporting. Project stewardship components include the following:

- Project maintenance
    - Projects that generate thermal benefits will be maintained based on specific maintenance plans to ensure projects reach maturity and continue to perform for the duration of the renewed operating license.
- Upland sediment reduction
    - To protect the habitat functions of the in-stream projects, IPC will implement sediment-reduction programs on agricultural lands upstream and within project reaches through a landowner incentive program.
    - Projects implemented and acreage treated will be tracked and reported annually.
    - Projects will be maintained by the landowner as confirmed by landowner agreements.

7.1.2.4. Adaptive Management and Program Review

Consistent with the phased and iterative implementation theme of the SR–HC TMDL, the TMCP will include an active adaptive management component designed and intended to instruct decision making, resolve uncertainty, and result in the improvement and potential modification of the SRSP and associated temperature measures.

7.1.2.4.1. Alternative or Supplemental Measures to the TMCP

This adaptive management approach will include consideration of alternative or supplemental measures and, as appropriate, inclusion of those measures as a component part of the TMCP. Based on the information developed by IPC, with the assistance of the TFT, IPC believes the implementation of the TMCP/SRSP, as proposed in this application, will be sufficient to address the thermal benefit milestones. However, as implementation of the SRSP proceeds, IPC will review and assess the progress of the program and identify and consider alternative or supplemental measures that may provide, or assist in providing, reasonable assurance that the thermal benefit milestones will be achieved. “Alternative or supplemental measures,” as used herein, means an alternative method, approach or amendment to the TMCP that will provide, or assist in providing, reasonable assurance that the thermal benefit milestones will be achieved or that addresses, or assists in addressing, other issues associated with the implementation of the TMCP.

The DEQs have indicated that a “Plan B” will be a requirement in this 401 process. This Plan B would identify an alternative measure that might be presented to, and considered, by the DEQs should the proposed TMCP/SRSP not be sufficient to address the thermal benefit milestones. The DEQs have expressly communicated the expectation that this Plan B should include an engineered measure, such as a hypolimnetic pumping system (HPS). Therefore, IPC includes a Plan B below.

7.1.2.4.1.1. Plan B

For over a decade, IPC has been analyzing and considering options or measures to address issues associated with water-temperature conditions downstream of HCD. In this application, IPC proposes a watershed-based approach designed to not only improve temperature conditions but also related water-quality and habitat conditions above, within and below the HCC.

Previously, IPC has also considered engineered approaches to improve temperature conditions, generically referred to as TCSs. A summary review of the consideration of various TCS options is included below. While IPC’s review of these TCS options indicates that temperature conditions downstream of the HCC can be influenced by the installation and operation of a TCS within the HCC, serious questions remain relating to the effect of operating a TCS on downstream and in-reservoir water-quality conditions, aquatic species, and their habitat. IPC is currently involved in a collaborative study in cooperation with the USGS to answer some of these questions, particularly those related to the fate and transport of methylmercury within and below the HCC. It is expected that this study and analysis effort will take multiple years (estimated between 7–10) to explore the many issues associated with the fate and transport of methylmercury and the effect of those issues on the potential for installing an HPS or other TCS that relies on the release of cool water from the hypolimnion of HCC reservoirs (see Section 6.6.2.2. Water Column for more information on the goals and schedule of the USGS study). As part of the SRSP reporting protocols, IPC will annually update the DEQs on the progress of this study effort.

Notwithstanding those serious unanswered questions, the DEQs have requested this application include an analysis of an HPS for reducing HCC outflow temperatures, should the proposed TMCP/SRSP not be sufficient to address the thermal benefit milestones. Therefore, as a Plan B, IPC proposes the installation of an HPS in Brownlee Reservoir, designed to blend cooler water from the lower strata of the reservoir with warmer upper-strata waters. This HPS was included as a proposed temperature measure in IPC’s September 24, 2010, 401 application. In that application, IPC concluded there was a sufficient volume of cold water in Brownlee Reservoir in October to cool historical conditions at the HCC outflow to meet the salmonid spawning temperature criterion and that in 95% of years analyzed, there was a sufficient volume of cold water in Brownlee to also provide a margin of safety relative to the availability of cold water (Exhibit 7.1-2).

The HPS proposed in 2010 consisted of a system of high-flow, low-head pumps designed to move cold water from the hypolimnion of Brownlee Reservoir to discharge into the intake channel in front of the turbine penstocks. An initial engineering assessment indicated this system was feasible to construct and operate (Exhibit 7.1-2). Subsequent engineering assessments (Exhibit 7.1-3) also indicate the construction is feasible and could consist of a floating platform that supports 20 axial flow pumps, each capable of pumping 250 cfs (maximum flow rate of 5,000 cfs) by suctioning cold water up through telescoping vertical fiberglass-reinforced pipes and transmitting the cold water horizontally through twenty 9-foot diameter delivery pipes to within about 200 feet of the Brownlee power intake structure. The 2,000-foot long delivery pipes are held together in 3 rows by 19 structural steel bands that are each connected to a float that keeps the pipes just under the reservoir water surface (Figure 7.1-11). The cold water discharged into the intake channel in front of the turbines would mix with warmer water being drawn through the powerhouse to cool Brownlee Project outflow during the period of operation. Cooler Brownlee Project outflows would then propagate through Oxbow and Hells Canyon reservoirs, resulting in cooler outflows from the HCD.

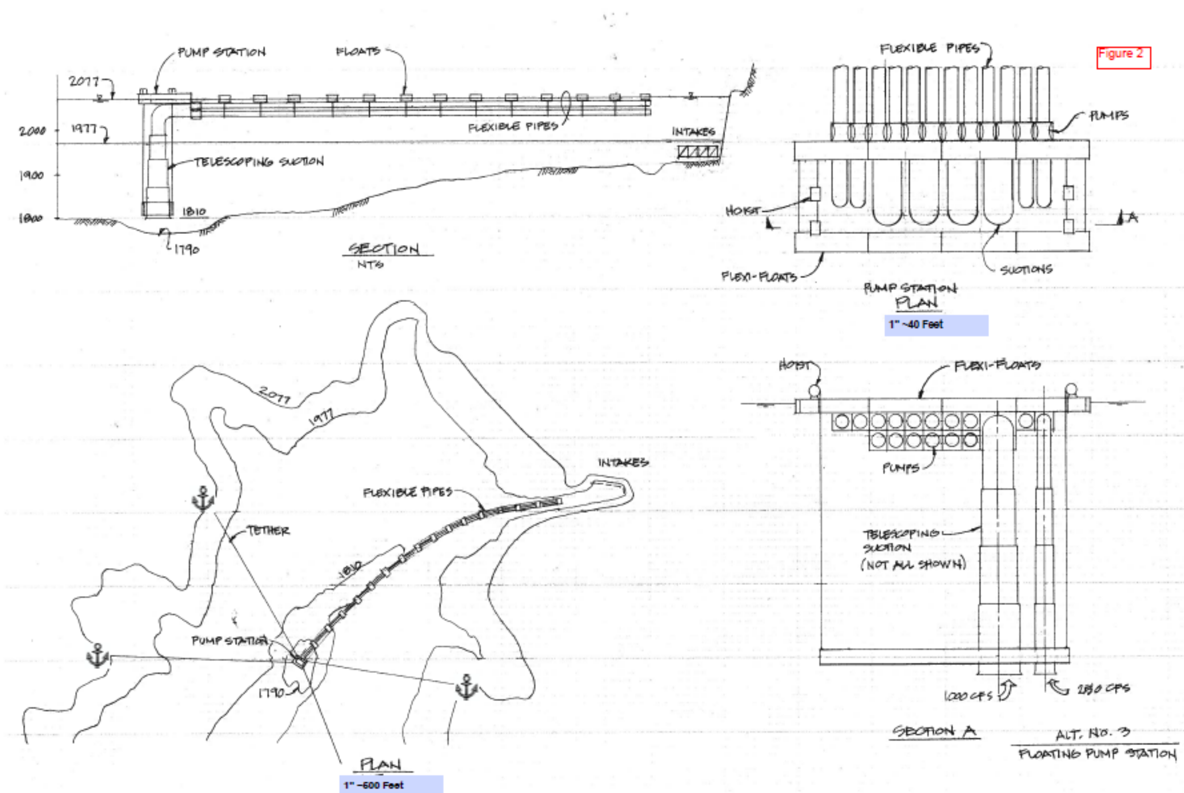


Figure 7.1-11
Brownlee cold-water pumping plan concept design sketch (Exhibit 7.1-3)

The September 2010 analysis relative to the ability for a conceptual HPS to meet temperature objectives was based on a flow-weighting analysis. The calculation used measured conditions in Brownlee Reservoir (i.e., temperature of the hypolimnion water) and temperature and flow rate at the outflow from HCD from 1991–2009 (i.e., the temperature exceedance of the salmonid spawning criterion and duration of the exceedance).

Excerpts from the 2010 application, Section 7.1.1:

The cold water temperature in Brownlee Reservoir, along with outflow temperature and flow from Hells Canyon Dam, were used in the flow weighting analysis. The basic equation shown below was used in this analysis and the cold water flow rate iteratively adjusted to meet 13.3 °C. This cold water flow rate was then used with the measured duration of the criteria exceedence for that year to estimate the cold water volume needed.

$$TempHC_{predicted} =(((FlowHC_{out}-Flow_{pump})*TempHC_{out})+(Flow_{pump}*Temp_{Hypo}))/FlowHC_{out}$$

Where:

- $TempHC_{predicted}$ *is calculated flow weighted HCC outflow temperature including cool water from Brownlee Project.*
- $FlowHC_{out}$ *is average HCC outflow from 10/23 to 10/29 for that year. This is representative of fall Chinook flows that are typically held flat through the period.*
- $Flow_{pump}$ *is flow of cool water from Brownlee Reservoir.*
- $TempHC_{out}$ *is measured 7-day average maximum HCC outflow temperature on October 29. This does not account for the "tapering" of the temperature exceedence over the duration of flows.*
- $Temp_{Hypo}$ *is volume weighted average hypolimnetic temperature below 1,920 ft msl in Brownlee Reservoir based on measured conditions for that year.*

Assumptions in this analysis include:

- *No tapering as exceedence declines, i.e., HCC outflow temperatures are assumed to be constant at the measured value for the duration of exceedence. Actual conditions are cooling (i.e., tapering) to 13 °C over the duration. This is a conservative assumption because a tapering, not constant, cold water flow rate would be sufficient to remain below criteria and would use less cold water volume.*
- *Future HCC outflows are similar to measured flows for specific years.*
- *Regionally managed flood control operations for Brownlee Reservoir will remain as they were historically. The hypolimnion temperatures in Brownlee are related to mandated flood control drawdowns of Brownlee Reservoir.*

Based on this flow weighting analysis there was sufficient volume of cold water in Brownlee Reservoir in October to cool historical conditions at the HCC outflow to meet the SR–HC TMDL load allocation (Table 7.1-2). In 95 percent of years analyzed, there was sufficient volume of cold water in Brownlee to also provide a margin of safety relative to the availability of cold water. With the exception of 1999, pumping rates from 1,000 to 4,200 cfs would be adequate for cooling the outflows.

In December 2010, in response to IPC's September 2010 401 application, the ODEQ submitted AIRs to IPC. As part of these AIRs, the ODEQ noted that the flow weighting analysis "does not address the possible attenuation of cold water as it moves through the Hells Canyon complex" and requested modeling of representative flow years to "simulate the flow of water as it moves through the three dam complex and address the possible attenuation of the cold water as it moves through the complex." To model the HPS and respond to the ODEQ AIRs, IPC's existing CE-QUAL W2 models were upgraded and customized by Scott Wells (Environmental Engineering). The custom coding allowed water to be withdrawn at a point in the hypolimnion of Brownlee and placed in the turbine intake channel. The coding also allowed the simulation of a variable pump flow rate, meaning the pump rate was calculated by the custom CE-QUAL-W2 coding based on a temperature target for the modeled Brownlee outflow and the turbine outflow rate. The results of the HPS modeling showed very similar results as the flow-weighting analysis in the September 2010 application and are detailed below in an excerpt from IPC's response to the ODEQ AIR. IPC's entire response is included as Exhibit 7.1-4.

Excerpt from IPC's March 2011 response to the ODEQ AIR on IPC's 2010 401 application:

> *Results of the HPS modeling indicate that the criterion can likely be achieved with the proposed HPS (Table 3 and Figures 1-5). Calculated 7-day average maximums on October 29 using hourly Hells Canyon modeled outflow temperature were at or below 13.3 °C for all years except 1999 which was at 13.6 °C (Table 3). Results for 1999 (and all years) should be evaluated in the context of model uncertainty and specific conditions (e.g. meteorological and hydrological) unique to that year. In both 2002 and 1995 a Brownlee outflow temperature target of 12.8 °C resulted in output that was cooler than the 13.3 °C criterion at Hells Canyon outflow. In 1992, the translation was not as direct and water did appear to warm and/or attenuate slightly as it moved through Oxbow and Hells Canyon Reservoirs. Overall, the modeling confirms the capacity of the proposed HPS in Brownlee Reservoir to achieve the necessary cooling to meet the criterion at Hells Canyon outflow in a broad range of water years (Figure 2, 3, 4 and 5). These results are similar to the results of mass balance analyses provided in Table7.1-2 of the 401 application.*

Table 3. Modeled Hells Canyon outflow temperature results as 7-day average maximum on October 29 for the 4 model years.

Model Year	*Baseline, no HPS (7-day average maximum °C)*	*HPS, variable flow (7-day average maximum °C)*	*Average pump flow rate for HPS variable (cfs)*
1992	*15.5*	*13.3*	*3395*
1995	*14.0*	*12.8*	*1865*
1999	*14.5*	*13.6*	*4292*
2002	*14.2*	*12.9*	*1476*

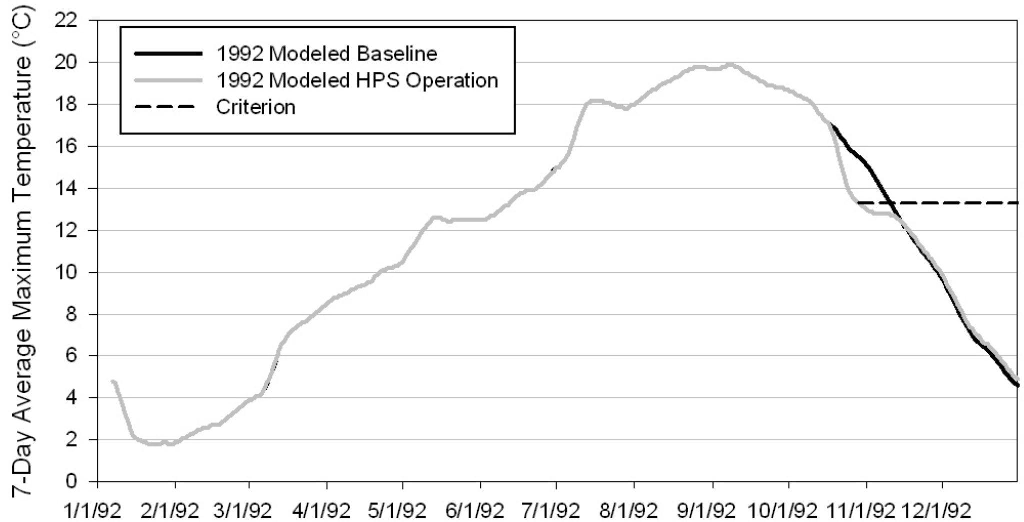


Figure 2. Modeled 1992 Hells Canyon outflow 7-day average maximum temperature for Baseline (no HPS) and HPS operation with CE-QUAL-W2 calculated pump flow rate.

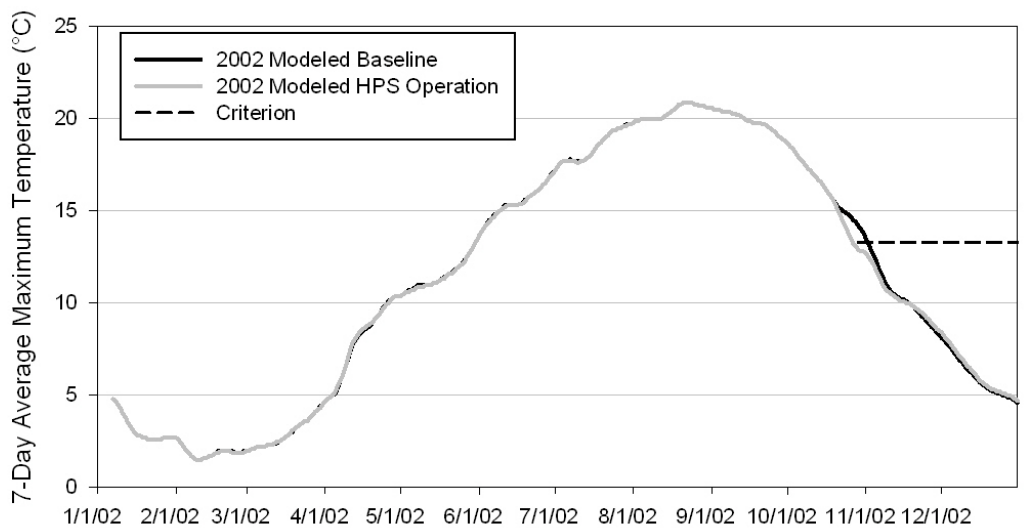


Figure 3. Modeled 2002 Hells Canyon outflow 7-day average maximum temperature for Baseline (no HPS) and HPS operation with CE-QUAL-W2 calculated pump flow rate.

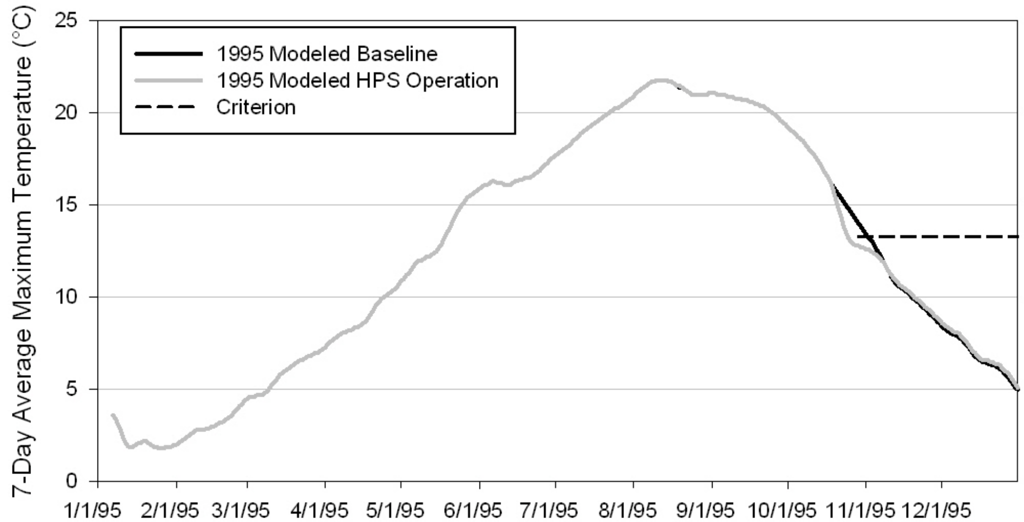


Figure 4. Modeled 1995 Hells Canyon outflow 7-day average maximum temperature for Baseline (no HPS) and HPS operation with CE-QUAL-W2 calculated pump flow rate.

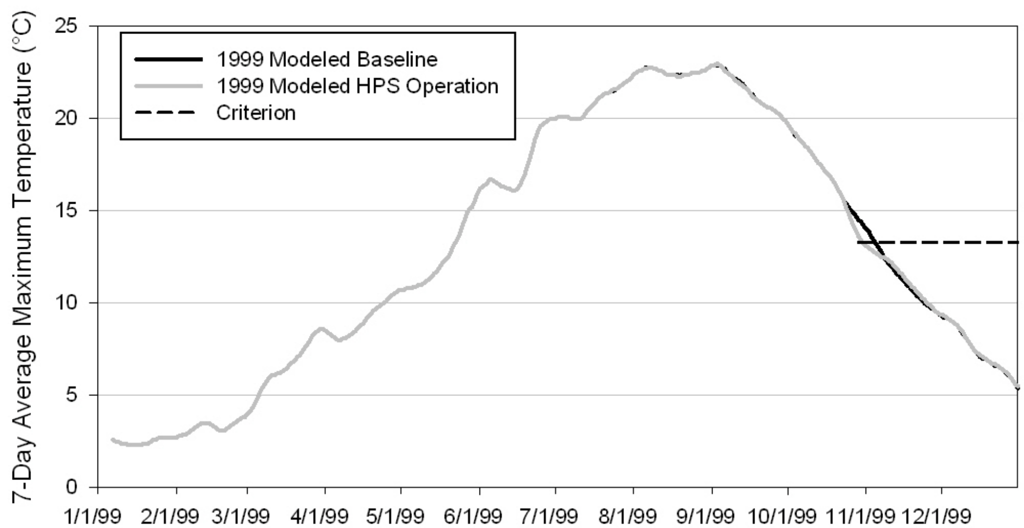


Figure 5. Modeled 1999 Hells Canyon outflow 7-day average maximum temperature for Baseline (no HPS) and HPS operation with CE-QUAL-W2 calculated pump flow rate.

Subsequent to IPC's March 2011 response to the 2010 ODEQ AIR, additional modeling was conducted by the University of Iowa to further evaluate the capability of an HPS (Exhibit 7.1-5). The specific objective was to evaluate the stability of the thermocline during the operation of a HPS and the ability of the HPS to draw cold hypolimnetic water without disturbing the thermocline and accessing warmer layers of the reservoir. Two stratification conditions (i.e., strong, 2002, and relatively weaker, 1999) were simulated to bracket the range of historical conditions seen in Brownlee Reservoir. During strong stratification conditions, the thermocline remained stable throughout the HPS operation, although the temperature of the pumped water increased slightly. During weaker stratification conditions (i.e., 1999), water was drawn from the hypolimnion and warmer layers of the metalimnion due to the elevation of the pump intakes and stratification in conditions in 1999. However, the pumped water was cooler than the baseline and resulted in cooling up to 1.2°C, tapering off to zero in about 12 days, which was similar to the results seen with the CE-QUAL-W2 modeling discussed previously (Exhibit 7.1-4).

The information summarized above and in exhibits 7.1-2, 7.1-3, 7.1-4, and 7.1-5 represent a detailed evaluation of the feasibility and efficacy of the HPS currently proposed as Plan B. Based on this collection of information, the HPS is feasible to construct and could be operated to meet the salmonid spawning criteria.

Consideration of an HPS, or other TCS, as an acceptable Plan B alternative measure is contingent on a finding by the DEQs and IPC that the operation of an HPS complies with all applicable water quality standards, including toxics and antidegradation, and has no adverse effect on in-reservoir or downstream aquatic species, their habitat, or on human consumers of such species (see Exhibit 7.1-2, Section 6.6 and Section 7.1.2.4.1.3 for more information on potential adverse effects). These considerations and findings are consistent with OAR 340-041-0028 (12)(g), which states, "Stored cold water may be released from reservoirs to cool downstream waters in order to achieve compliance with the applicable numeric criteria. However, there can be no significant adverse impact to downstream designated beneficial uses as a result of the releases of this cold water, and the release may not contribute to violations of other water quality criteria. Where the Department determines that the release of cold water is resulting in a significant adverse impact, the Department may require the elimination or mitigation of the adverse impact."

As indicated above, as part of the adaptive management component of the TMCP, IPC will continue to identify and consider alternative or supplemental measures that may provide, or assist in providing, reasonable assurance that the thermal benefit milestones will be achieved and reserves the right to amend or modify this proposed Plan B by including or substituting additional or alternative measures. Such a progressive review process will allow IPC, and the TMCP, to benefit from new and advancing technologies.

7.1.2.4.1.2 Consideration of Alternative or Supplemental Measures

At any time during the term of the TMCP/SRSP, IPC may present to the DEQs for consideration an alternative or supplemental measure that may provide, or assist in providing, reasonable assurance that the thermal benefit milestones will be achieved, or that addresses, or assists in addressing, other issues associated with the implementation of the TMCP. In connection with the second 5-year review, the DEQs may also consider whether implementation of Plan B is necessary to achieve compliance with the 15- and 30-year compliance targets established by the 401 certification; see Section 7.1.2.3.5. Ongoing Milestones, Project Tracking, Monitoring, and Reporting.

A proposal by IPC to the DEQs that alternative or supplemental measures to the SRSP should be considered shall be in writing and, at a minimum, include the following:

1. The basis or reason why IPC considers alternative or supplemental measures to the SRSP to be necessary or appropriate

2. A detailed description of the proposed alternative or supplemental measure

3. An analysis of the how the alternative or supplemental measure will provide, or assist in providing, reasonable assurance that the HCC temperature load allocation will be achieved, or that such measure should be considered because it addresses, or will assist in addressing, other issues associated with the SRSP, including costs

4. A statement of whether the proposed alternative or supplemental measure will comply with applicable water-quality standards, including antidegradation, or otherwise adversely affect in-reservoir or downstream aquatic species or their habitat.

Within 60 days of receipt of the written proposal by IPC that alternative or supplemental measures to the SRSP should be considered, the DEQs shall meet with IPC and discuss the proposal and any additional information that may be required by the DEQs for its consideration. Thereafter, within 60 days of the meeting with the DEQs and the submission of any necessary additional information, the DEQs shall notify IPC in writing of its approval or rejection of the proposed alternative or supplemental measures. If rejected, the DEQs shall specify, in detail, the basis for the rejection. Within 120 days of a DEQ approval, IPC shall submit to the DEQs an Alternative or Supplemental Measures Plan with details relating to the implementation of the approved measure.

Consideration by the DEQs of whether a Plan B is necessary to achieve compliance with the 15- and 30-year thermal benefit milestones established by the 401 certification will occur in connection with the second 5-year review in year 10 following license issuance. Within 60 days of the submission to the DEQs of the second 5-year review statement, IPC shall meet with the DEQs to review the statement and discuss, among other relevant issues, whether any data provided or issues raised by the statement indicate that the SRSP, as implemented to date, is not reasonably expected to achieve compliance with the 15- and 30-year compliance targets established by the 401 certification and whether implementation of “Plan B”, or another alternative or supplemental measures to the SRSP, may be necessary or advisable to reasonably ensure compliance. In determining whether implementation of a Plan B or other measure may be necessary or advisable, the DEQs shall consider the following:

1. Taking into account any previously approved revisions to the SRSP, whether projects implemented and to be implemented under the SRSP appear reasonably likely to achieve the year 15 and 30 thermal benefit milestones (see Section 7.1.2.3.5. Ongoing Milestones, Project Tracking, Monitoring, and Reporting).

2. Whether Plan B or the alternative measure being considered, operated alone or in combination with other alternative measures, after consideration of any mercury or other water quality studies undertaken, and any other information the DEQs deem relevant, may cause or contribute to a violation of applicable water quality standards, including antidegradation, or otherwise adversely affect in-reservoir or downstream aquatic species or their habitat.

3. Other issues relevant to the consideration of Plan B or an alternative measure, including whether the construction or implementation of the measure may require any permitting or approval by any state or federal agency, including FERC.

Within 60 days of the meeting with IPC to review the second 5-year review statement, the DEQs shall notify IPC, in writing, of a determination that the implementation of Plan B, or another measure is necessary to reasonably ensure compliance with the year 15 and 30 thermal benefit milestones. Within 120 days of the DEQ notification, IPC shall submit a Plan B or Alternative Measures Plan for DEQ review and approval that contains the following:

1. Details of the measure to be implemented, including a comparison of the proposed measure to the current SRSP, and the originally approved SRSP.

2. An evaluation of whether the measure may cause or contribute to a violation of applicable water-quality standards or otherwise adversely affect in-reservoir or downstream aquatic species or their habitat, and, if so, whether there are any actions that can be undertaken to ensure no such violations or adverse effects occur.

3. If the construction or implementation of the measure may require permitting or approval by any state or federal agency, a description of the process necessary and the estimated time period to acquire such permitting or approval.

4. A schedule for the implementation of the measure.

IPC will continue to implement the SRSP in a manner consistent with the approved 401 certification until a Plan B Measures Plan or an Alternative or Supplemental Measures Plan is approved by the DEQs. Either plan may include a reduction in the size or scope of the SRSP if Plan B or the alternative or supplemental measure, in conjunction with the reduced SRSP as proposed in the Plan, provides reasonable assurance that the thermal benefit milestones will be achieved. Upon approval of a Plan B or an Alternative or Supplemental Measures Plan by the DEQs, IPC will implement the plan, including any modifications to the SRSP, in accordance with the Plan’s terms and implementation schedule.

7.1.2.4.1.3 Summary Review of TCS Options

In the early years following the filing of IPC’s draft license application in 2003, the primary focus of these efforts relating to changing temperature conditions below HCD was on a TCS of some kind. Analyses of TCS options, and the potential effects of those options, were prompted by a 2004 AIR by FERC asking IPC to prepare and file a “conceptual design report on alternative designs for TCSs that could be installed at Brownlee intake…to enhance conditions for SRFC spawning, incubation, rearing and migration in the Hells Canyon reach” [37] (Exhibit 7.1-6). In that AIR, FERC commented on the motivation for the request:

[37] FERC AIR, May 4, 2004.

> Nearly all of the agencies, Tribes, and NGOs involved in this proceeding have requested that you [IPC] evaluate the potential benefits of modifying the Brownlee intake to allow the depth of withdrawal to be adjusted to provide some control over the temperature of water that is discharged from the project. Your application, however, provides little information about this potential enhancement measure. In our EIS on this licensing action, we will need to consider the costs and benefits of this and other measures that could protect and enhance aquatic resources. Therefore, you should evaluate this measure and provide the information that is listed below. We will use this information to examine the effects of variable level releases in terms of improving the reproductive success and growth of fall Chinook and effects on other aquatic resources downstream of the project. *Id*.

With the receipt of this AIR, designated as WQ-2, IPC embarked on a multi-month process of study and analysis of the potential design and efficacy of 3 TCS options. [38]

During this same time period, IPC was engaged in discussions with FERC, NOAA Fisheries and the FWS with regard to the potential effect of the interim operation of the HCC in advance of relicensing on species listed under the ESA. In fall 2004, these discussions led to the establishment of a Settlement Working Group (SWG) comprised of various relicensing stakeholders and separate FERC staff. [39] The initial objective of the SWG was to address interim operations and the effect of those operations on aquatic species listed under the ESA. In late 2004, twelve (12) of the SWG participants[40] entered into an Interim Agreement to address issues relating to HCC operations and ESA-listed species in advance of relicensing (Exhibit 7.1-7). This Interim Agreement was filed with FERC on January 7, 2005. Subsequent to the filing of the Interim Agreement, the SWG continued with the discussion of broader relicensing issues with the intent of developing a comprehensive settlement for the relicensing of the HCC. Among other things considered by the SWG was the data and information that IPC was developing in response to FERC AIR WQ-2 relative to temperature and the potential installation of a TCS within Brownlee Reservoir.

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[38] IPC evaluated 3 TCS alternatives: a stop-log weir, a gated weir and tunnel, and a 35-thousand cfs tower.

[39] Parties participating in the SWG included IPC, NOAA Fisheries, the FWS, BLM, USBR, USFS, USACE, EPA, State of Oregon, State of Idaho, Nez Perce Tribe, Shoshone–Bannock Tribes, Burns–Paiute Tribe, American Rivers, Confederated Tribes of the Umatilla Indian Reservation, Columbia River Inter-tribal Fish Commission, Idaho Rivers United, Idaho Water Users Association, Payette River Water Users Association, Pioneer, Settlers and Nampa Meridian irrigation districts, Committee of Nine, Idaho Farm Bureau, Idaho Council on Industry and Environment, J.R. Simplot Company, Malheur County (Oregon), Adams and Washington counties (Idaho), and the Idaho Association of Counties.

[40] The Interim Agreement was signed by IPC, NOAA Fisheries, the FWS, USFS, BLM, Idaho Rivers United, American Rivers, ODEQ, ODFW, Shoshone–Paiute Tribes, Nez Perce Tribes, and Shoshone–Bannock Tribes. The State of Idaho did not sign the Interim Agreement but submitted a letter (included in Exhibit 7.1-7) supporting the settlement process.

FERC's May 4, 2004, AIR requested IPC respond to the WQ-2 AIR within 9 months, or by February 2005. IPC requested extensions of time for the filing of those responses to allow for the SWG to consider the information being developed. Draft responses to the AIR were shared and discussed with the SWG. In an effort to determine whether the installation and operation of a TCS in Brownlee would benefit SRFC emergence and migration, in April of 2005 IPC entered into a contract with the USACE to model the impact of the installation of a TCS in Brownlee on water temperatures in the Snake River at the Lower Granite Dam tailwater. The results of this modeling were discussed with the SWG and included in IPC's final response the WQ-2 AIR filed with FERC on September 30, 2005[41] (Exhibit 7.1-8), and also in IPC responses to FERC comments in October 2005 (Exhibit 7.1-9). In that response, IPC summarized the reports' conclusions:

> Using the Corps modeling results, IPC, in conjunction with NOAA Fisheries, subsequently completed an analysis of the effect of changing the outflow temperature from Hells Canyon Dam, by installing and operating a TCS in Brownlee, on the timing of emergence of juvenile fall Chinook below Hells Canyon dam and the survival of those juveniles at the Lower Granite tailwater. Generally, this analysis concluded that installing a TCS at Brownlee and operating the structure in low water years to cool outflows in an attempt to meet the salmonid spawning water quality standard of 13° C below Hells Canyon Dam offsets any benefit of attempting to influence earlier emergence of juvenile fall Chinook from operating the TCS for spring warming. This analysis, when considered with the other information developed with regard to the operation and effect of installing a TCS at the HCC, leads to the following conclusions: water temperatures cannot be warmed sufficiently in the spring to provide significant benefit to incubating fall Chinook salmon, e.g., the change in emergence timing is relatively modest; operating the TCS to cool outflows in the fall in an effort to meet the existing water quality standard for salmonid spawning actually results in a delay in spring emergence timing, thereby offsetting any benefit of the spring operation; and, finally, the installation and operation of a TCS at Brownlee Dam in an attempt to meet either of these objectives actually results in a lower survival of juvenile fall Chinook through Lower Granite Reservoir. *Id.*

Although the potential effect of operating a TCS on overall water quality within and below the HCC was not the primary focus of the FERC AIR, IPC also concluded that the operation of the type of TCS evaluated in the AIR would raise the elevation of the thermocline in Brownlee Reservoir, thereby changing the thermal structure of the reservoir and altering the physical, biological, and chemical processes occurring in Brownlee Reservoir. The operation of a TCS would therefore likely result in the release of increased anoxic and toxic laden (including mercury) water downstream. Based on the modeling results and these preliminary water quality findings, in the AIR response IPC advised FERC it was not advisable to install a TCS at the HCC. NOAA Fisheries, a member of the SWG and a collaborator on the USACE temperature modeling, reached a similar conclusion:

[41] Responses to FERC AIR WQ-2(c), Detailed Evaluation of Alternative Temperature Control Structures, September 2005.

> Temperature Control: The temperature of the Project release water is an issue of concern to NMFS and we worked extensively with IPC to investigate several temperature control measures at the project and various strategies for using these structures during the relicensing study period. Based on this information, NMFS concluded that these structures would not provide the substantial benefits to incubating, rearing, migrating, or spawning fall Chinook that the agency had hoped would be attained with these structures. While we believe that this effort was thorough, we have no objection to further consideration or analysis of methods to improve discharge water temperatures, particularly if new or innovative approaches can be found[42] (Exhibit 7.1-10 and 7.1-11).

The SWG settlement process concluded in fall 2005 without a comprehensive settlement. Thereafter, IPC continued to work with the ODEQ and IDEQ on 401 certification issues, including the fall temperature load allocation assigned to the HCC by the SR–HC TMDL. In light of the 2005 TCS analysis, which raised questions as to the benefits and potential adverse effects from operation of a TCS, from 2006 through 2009 the focus of IPC's efforts on temperature centered around an upstream watershed approach to address water-temperature conditions above and below the HCC. In 2009, IPC submitted a § 401 application to the DEQs proposing an upstream watershed improvement program, identified as the *Temperature Enhancement Management Plan* (TEMP), intended to address the HCC temperature load allocation and improve overall water quality and habitat conditions above and within the HCC. NOAA Fisheries and the FWS expressed support for the proposal, but the EPA, and other downstream interests, opposed it, in large part because of perceived issues concerning appropriateness of the modeling boundary conditions relied on by IPC in the development of the watershed program. This resulted in uncertainties in the size and feasibility of the TEMP watershed program and ultimately IPC's withdrawal of the application in December 2009.

After several months of discussions with the DEQs, in September 2010 IPC filed a new § 401 application. In Section 7.1. Temperature Proposed Measures of this application, IPC addressed the SR–HC TMDL load allocation by proposing the installation of a hypolimnetic pump system (HPS) in Brownlee Reservoir designed to meet the SR–HC TMDL load allocation assigned to IPC below HCD by blending cold water from the lower strata of Brownlee Reservoir with warmer upper-strata water. [43] (Exhibit 7.1-2). While IPC submitted that the proposed HPS would adequately address the HCC load allocation and applicable salmonid spawning temperature criteria, it cautioned, as it did in the 2005 response to the FERC AIR for WQ-2, that the operation of the HPS, or any other TCS that accesses and moves water from the hypolimnion of Brownlee Reservoir downstream, poses a level of risk for natural resources in the river and the 3 reservoirs within the HCC and that the precise nature and extent of these risks could not be

[42] November 3, 2006, NMFS comments to FERC Draft Environmental Impact Statement for the HCC, p. 39 (Exhibit 7.1-10). Not everyone agreed with the IPC/NOAA conclusions; see EPA comments to Draft Environmental Impact Statement, November 3, 2006 (Exhibit 7.1-11).

[43] Section 401 Water Quality Certification Application—Hells Canyon Complex, FERC No. 1971 (September 2010).§ 7.1 of that Application, Temperature Proposed Measures, is attached as Exhibit 7.1-2.

determined until the HPS is constructed, operated, and the effects on in-reservoir and downstream resources analyzed:

> In October, the cold water in the hypolimnion of Brownlee Reservoir is anoxic and pumping this water to the intake channel to be drawn through the turbines will correspondingly result in reduced DO immediately downstream of Brownlee Reservoir and at the HCC outflow. Increased levels of methane, sulfides, dissolved nutrients, methylmercury and other dissolved inorganics associated with the anoxic conditions in the hypolimnion of Brownlee Reservoir may also be released downstream. Some of these products (e.g., methane, sulfides) are oxidized when oxygen is added to the water and can create additional oxygen demand. Others, such as methylmercury are a concern due to aquatic toxicity. *Id., pg. 154.*

IPC's proposal to install and operate an HPS in Brownlee Reservoir to address the downstream temperature standard elicited negative reaction from the FWS and NOAA Fisheries:

> At this point, the effects of a deep water withdrawal system that may affect the dynamic processing balance in Brownlee Reservoir are little understood. Furthermore, potential oxygen reduction and contaminant transport to downstream species is a threat of unknown magnitude…Unfortunately, history has shown that engineered solutions to a perceived resource problem addressing one narrow issue, in this case temperature, may have multiple adverse resource effects that may not be evident until final construction and operation. In the case of the HPS, the Service is concerned that we may again be creating a narrow solution to a discreet aquatic habitat issue while ignoring, and possibly damaging, other resources within the HCC and the Snake River watershed. [44] (Exhibit 7.1-12)

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> NMFS does not support this application because it does not focus on the broader set of water quality issues at an ecosystem scale that affect anadromous fish in the Snake River…In other words, the abundance and productivity of naturally produced SR fall Chinook in this [HC] reach does not appear to be limited by water temperatures in the reach, but by the amount of quality juvenile rearing habitat (space) available in the reach…IPC's most recent 401 application proposes to meet ODEQ's numerical water temperature standard for spawning salmon by pumping cooler water from deep in Brownlee Reservoir into the intake channel for the Brownlee powerhouse, cooling the discharge to the Snake River at Hells Canyon Dam. This plan itself causes NMFS concern due to water quality issues associated with nutrients and toxics; however, it does not cause us concern with respect to temperature…The proposed TCS would not provide any additional spawning and rearing habitat, which is what is needed to benefit the species at this point. NMFS does not believe that meeting spawning water temperature standards would appreciably increase either the abundance or the productivity of

[44] FWS comments on Idaho Power's water-quality application for the HCC, November 15, 2010.

> spawning aggregate in the Hells Canyon reach of the Snake River. We are also concerned that by entraining water from depth in Brownlee Reservoir into the discharge stream from the project, additional risks to the existing SR fall Chinook population and its critical habitat would be incurred. These risks include low dissolved oxygen concentrations, high nutrient (nitrogen and phosphorus) concentrations resulting in high biological oxygen demand, and toxins (DDT, and other pesticides and herbicides and heavy metals, particularly methyl-mercury).[45] (Exhibit 7.1-13)

In December 2010, in response to IPC's September 2010 § 401 application, the ODEQ submitted AIRs to IPC. These AIRs included inquiries related to the potential risks of installing and operating an HPS. In this context, the ODEQ asked IPC to further describe "what water quality conditions, throughout the project, could be exacerbated by the discharge of water from Brownlee Reservoir's hypolimnion…discuss all available data indicating these risks and define data gaps." The ODEQ also advised that in considering the application, it must complete an antidegradation review and asked IPC to "describe specifically how water quality within Brownlee Reservoir and downstream water quality and beneficial uses will be affected by the blending of cooler water from Brownlee Reservoir (Exhibit 7.1-14). [46]

IPC responded to the ODEQ AIR on March 11, 2011, including in the response available data and information relating to toxic levels in Brownlee Reservoir, much of which was developed for the relicensing of the HCC (Exhibit 7.1-4).[47] IPC noted that the presence of toxic materials in the hypolimnetic waters of Brownlee had received only limited study during the relicensing process and that the potential risks and water-quality issues associated with the operation of the proposed HPS remained uncertain. The filing of this response fostered further discussion and ultimately a collaborative study effort by IPC, the FWS, and the DEQs to better assess toxic levels in Brownlee Reservoir (see Section 6.6. Toxics for more information on toxics). Over time, these efforts have increasingly focused on the level of mercury in Brownlee and the fate and transport of that constituent downstream (see Section 6.6. Toxics for more information on toxics in the HCC). This evolution resulted in IPC's participation in a large study effort headed by the USGS, which began in 2014, is ongoing, and is anticipated to extend for 7 to 10 years. IPC plans to continue participating in this effort for the duration of the study.

Due to the ongoing and uncertain risks associated with the operation of a HPS (or TCS) within Brownlee Reservoir on downstream resources, in July 2011 IPC withdrew the September 2010 § 401 application and submitted a new application without sections 6.1 and 7.1

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[45] NOAA Fisheries comments on IPC's water-quality application for the HCC, January 27, 2011. NOAA's comments on the September 2010 HPS proposal reflect a consistency with its 2003 comments to the EPA on the *Region 10 Guidance for State and Tribal Temperature Water Quality Standards*, where it said large federally-licensed dams were already subject to extensive regulation under the ESA and FERC licensing proceedings and that temperature effects should be considered in combination with other project effects as part of a comprehensive consultation.

[46] ODEQ AIR, HCC Application for Certification under CWA § 401, December 6, 2010.

[47] IPC responses to ODEQ AIR, March 11, 2011.

relating to temperature. Subsequent to this submission, IPC continued to work with DEQ staff on alternatives for addressing the HCC temperature load allocation. These discussions continued through 2011, 2012, 2013, and 2014 with annual withdrawals of the pending § 401 applications and submissions of new applications. IPC retained TFT as a consultant to assist with the analysis and planning of an upstream watershed program to improve temperature conditions within, and downstream of, the HCC. In 2013, as consideration of an upstream watershed program continued, IPC explored the option of augmenting the temperature benefits realized from an upstream program with the installation of small HPS in Hells Canyon Reservoir (Exhibit 7.1-15).[48] Like Brownlee Reservoir, HCR accumulates cool water in its hypolimnion in lower water years, although the approximate potential volume of the HCR HPS design is significantly less (approximately 20,000 acre-feet in HCR as compared to approximately 150,000 acre-feet in Brownlee Reservoir), thereby providing the potential to supplement the upstream watershed temperature benefits and partially address the HCC temperature load allocation. IPC explored this option under the assumption that because HCR was smaller than, and downstream from, Brownlee, the mercury and toxic levels of the reservoir would be much less than in Brownlee Reservoir. Subsequent study and analysis, however, indicated that this does not appear to be the case, and IPC ultimately set this option aside until the studies referenced previously provide more information as to the presence, fate, and transport of mercury.

7.2. DO Proposed Measures

In order to fully mitigate the negative effects of the HCC on DO, IPC is proposing three measures. First, the Riverside Operational Water-Quality Improvement Project will fully address the 1,125 ton per year DO load allocation assigned to Brownlee Reservoir in the SR-HC TMDL. Second, distributed aeration systems in 4 of the 5 units in Brownlee Powerhouse, that will provide, at a minimum, DO increases of 0.2 mg/L to 0.4 mg/L that will address the current negative effects of Hells Canyon Reservoir on outflow DO and also address any DO deficit relative to meeting the downstream standard under full SR-HC TMDL implementation. Specifically, the distributed aeration systems will also add 0.4 mg/L of additional oxygen below HCD during the beginning of the salmonid spawning period that has been identified by modeling conducted cooperatively between the DEQs and IPC as part of the 401 application process. These additions will be accomplished by operation of the proposed aeration system in a way that maximizes aeration without resulting in causing problematic levels of other water quality constituents such as TDG. This aggressive approach to implementation of the aeration will also provide additional benefit relative to uncertainty in future conditions. Third, a destratification system in the deep pool in the Oxbow Bypass to address thermal stratification and resulting anoxic conditions at that location.

[48] *Hells Canyon Surface Collector with Temperature Management Component: Conceptual Design Report Executive Summary*.

7.2.1. Upstream Watershed Phosphorus Trading

7.2.1.1. Riverside Operational Water-Quality Improvement Project

IPC is proposing to address its DO load allocation assigned to the transition zone and metalimnion of Brownlee Reservoir in the SR–HC TMDL (IDEQ and ODEQ 2004) by implementing the Riverside Operational Water-Quality Improvement Project (ROWQIP). The SR–HC TMDL identified the HCC CWA § 401 certification as the process for detailing IPC's implementation plan for the required DO improvements. Following is a description of the proposed project and the supporting documentation to ensure the project is transparent, reliable, and verifiable.

To meet the SR–HC TMDL allocation, IPC developed the ROWQIP with the intent that the Riverside Irrigation District (Riverside) will operate its primary delivery facility (Riverside Canal) in a way that reduces the loads of phosphorus and other pollutants discharged from the Riverside Canal to the Boise and Snake rivers. The studies and analyses discussed below show that the ROWQIP as currently implemented by Riverside will meet IPC's DO requirements identified in the SR–HC TMDL (Exhibit 7.2-1).

Riverside implemented the water-quality improvement operations in 2014, prior to acceptance of this program in the HCC CWA § 401 certification or FERC license. This early implementation of ROWQIP, relative to IPC's regulatory requirements, enables Riverside to withdraw less water from the Boise River, reduces Riverside's regulatory compliance costs and provides immediate water quality benefits. By initiating implementation of the program, including constructing control systems, establishing flow monitoring stations, and testing operations (Exhibit 7.2-2) prior to program approval by the regulatory agencies, IPC has collected and analyzed data to ensure the value of the program toward meeting its SR–HC TMDL responsibility for DO in Brownlee Reservoir. Data collected and analyzed since 2010 supports a high level of certainty that the expected benefits in phosphorus load reductions to the Snake and Boise rivers occurred in 2014 and will continue to occur in future years.

7.2.1.1.1. Program Description

Riverside operates the Riverside Canal, located at the western end of the Boise River valley near the confluence of the Boise and Snake rivers, as its primary conveyance for the delivery of irrigation water (Figure 7.2-1). Riverside delivers water to approximately 230 water users for agricultural purposes, with principal crops of onions, sugar beets, wheat, potatoes, alfalfa, beans, and hops. According to IDWR records, Riverside has water rights authorizing the irrigation of 10,158 acres within a district boundary (IDWR 2013). The primary diversion to the Riverside Canal is from the south bank of the Boise River near Caldwell (Figure 7.2-1). Additionally, a number of tributaries and drains discharge into the canal along its length. Excess canal inflows are discharged (i.e., spilled) to the lower Boise and Snake rivers upstream of Brownlee Reservoir.

The ROWQIP was designed for automatic operation of the Riverside Canal in a manner that reduces phosphorus loading to the Boise and Snake rivers. The load reductions are accomplished by prioritizing the use of high-nutrient agricultural and municipal drainage water for delivery to irrigators and thereby reducing agricultural return flows to the Boise and Snake rivers.

Specific actions are described and defined in the canal operating guidelines (Exhibit 7.2-2—Appendix 1). In addition, the project was designed to be consistent with generally accepted quality standards and guidelines.

Under historical operations, water in Indian Creek and the West End Drain enter the Riverside Canal, along with Riverside's water-right diversion from the Boise River. Because of the configuration of the canal system, Riverside had no operational option other than to accept the water from Indian Creek and the West End Drain into its canal. At times, flows entering the Riverside Canal from Indian Creek and the West End Drain are variable and unreliable. Consequently, under baseline conditions, Riverside's necessary operation was to divert up to its water right from the Boise River. This ensured sufficient water for irrigation demand. If the total flow into the Riverside Canal exceeded irrigation demand, excess water was spilled back into the Boise and Snake through 4 spill gates along the canal and a spill at the end of the canal. The lack of system automation precluded operations capable of efficiently dealing with the variability of inflows from Indian Creek, the West End Drain, and other minor inflows. Consequently, more water was typically diverted from the Boise River than would be necessary under improved, more efficient operations proposed under the ROWQIP. Baseline diversion from the Boise River was consistent with the decreed water rights and was a practical necessity to meet irrigation demand because of the lack of operational flexibility and efficiency under the pre-ROWQIP system design.

The current operations, made possible by the ROWQIP, allow Riverside to preferentially use water with relatively high phosphorus levels for irrigation purposes, rather than spilling it into the Boise or Snake rivers. The result is reductions in phosphorus loading to the Boise and Snake rivers. The reduced phosphorus loading to the rivers will result in corresponding reductions in phosphorus and organic matter loading to Brownlee Reservoir. IPC is proposing to use the reduction in oxygen demand in Brownlee Reservoir resulting from the reduction of phosphorus and organic matter loading to Brownlee Reservoir to meet its DO load allocation defined in the SR–HC TMDL.

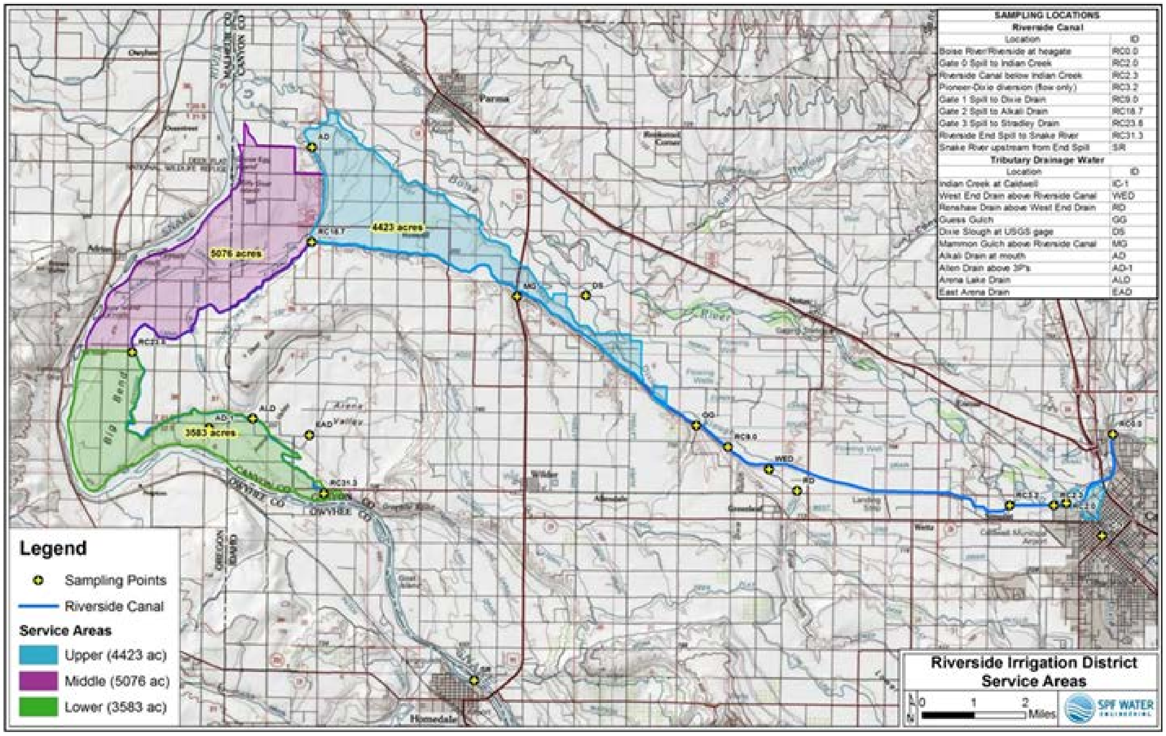


Figure 7.2-1
Riverside Irrigation District, approximate irrigated acreages, and sampling locations, including spill gates

7.2.1.1.2. Equivalent Phosphorus Load

To address DO concerns in Brownlee Reservoir, the SR–HC TMDL allocated an annual DO supplementation of 1,125 tons to IPC. The SR–HC TMDL specifically allows IPC to use upstream nutrient reduction to satisfy this requirement to improve DO levels in the transition zone and metalimnion of Brownlee Reservoir.

Based on typical stoichiometry, an equivalent seasonal phosphorus load reduction to IPC's 1,125 tons of oxygen requirement is 15,000 pounds (lbs) of phosphorus (Exhibit 7.2-2 – Appendix 2). This equates to an average phosphorus load reduction of 82 lbs per day over a 183-day irrigation season, the period the Riverside Canal is typically operated. This time period is appropriate considering the overall benefits of the inflow load reductions related to long-term storage and cycling of phosphorus within the reservoir. Given the dynamic nature of phosphorus spiraling in a phosphorus-rich riverine system, such as the Snake River and Brownlee Reservoir (ODEQ and IDEQ 2004), it is justifiable to assume all phosphorus released into the rivers through Riverside's system has practical implications for the DO dynamics in Brownlee Reservoir. Further, the phosphorus reductions upstream of Brownlee Reservoir provide additional water quality benefits for the lower Boise River and the Snake River immediately upstream of Brownlee Reservoir.

As stated previously, the SR–HC TMDL DO load allocation is 1,125 tons as an annual load. In the SR-HC TMDL, the assumed approach to meet this allocation was reservoir aeration over a low DO critical period from July 1 through September 7. While this was the time period of potentially lower DO conditions in Brownlee Reservoir, the SR-HC TMDL states, "this time frame should not be interpreted as an absolute requirement" (IDEQ and ODEQ 2004). The relatively short 65-day time period was based on the understanding that potential DO additions that were assumed possible through reservoir aeration would have no benefits outside the actual time period when aeration was occurring. Conversely, reductions in phosphorus and organic matter loading address the underlying problem of excessively high oxygen demand. Therefore, phosphorus load reductions outside the specific critical DO time period will still affect the actual DO levels within the critical period.

The typical time period that phosphorus loading will be reduced to the Boise and Snake rivers under this proposal is 183 days beginning April 15 and extending to October 15 (Exhibit 7.2-2 – Appendix 2). Under current phosphorus levels, the project can reduce seasonal phosphorus loads by levels that exceed the calculated equivalent to the DO allocation. The TP reductions provided by the ROWQIP address the underlying causes of low DO and have cumulative benefits that occur throughout the year, as well as across many years. For this reason, it is appropriate to calculate the load reductions resulting from the implementation of the ROWQIP over the irrigation season.

7.2.1.1.3. Phosphorus-Reduction Calculation Methodology

The phosphorus-load-reduction calculation methodology (Exhibit 7.2-2—Appendix 3) uses a mass balance analysis to determine the TP load (lbs per day) delivered to areas irrigated with Riverside Canal water. By changing the canal operations, such as diverting less Boise River water, more water from other sources, such as Indian Creek, is used for irrigation. Consequently, less of the water that is higher in phosphorus is discharged to the Boise and Snake rivers.

A Riverside Canal model was developed to estimate the TP loads that would be delivered in irrigation water under different canal operations. A simplified schematic diagram (Exhibit 7.2-2—Appendix 3) shows conceptually how the canal is structured with water diverted from the Boise River and a tributary containing drainage water discharging into the canal. Any excess drain water then "spills" back to the river downstream of the diversion along with agricultural runoff. The change in TP load in the river is calculated using delivered and runoff loads because it reduces uncertainty by relying on the same measurements for canal inflows and agricultural water delivery when modeling loads for differing canal operations.

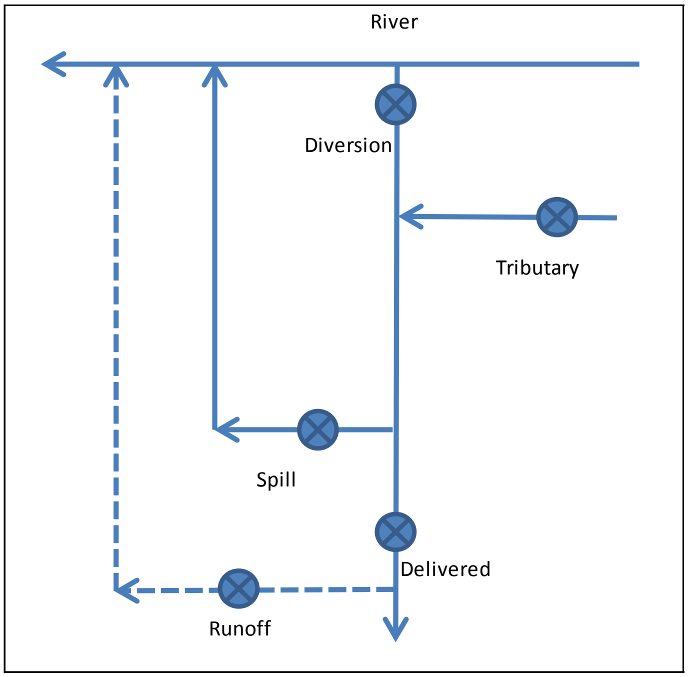


Figure 7.2-2
Simplified schematic of ROWQIP showing main components of the phosphorus-reduction calculation methodology

Using a mass balance approach, the TP load delivered to farm land (L Delivery) under various canal operations is calculated as follows:

$$\textbf{Equation 1}: L_{Delivery} = L_{Diversion} + L_{Tributary} - L_{Spill}$$

Where:

$L_{Diversion}$ = the load delivered to agricultural areas

$L_{Tributary}$ = the tributary inflow load

L_{Spill} = the load spilled back to the river

A change in the canal operations, such as diverting less Boise River water, will change the load in the canal because the various sources of water to the canal have differing water quality. Consequently, this changes the load delivered to the farm land. The automated operations of the canal under the proposed ROWQIP are designed to reduce phosphorus loading to the Boise and Snake rivers and are referred to as water-quality (WQ) operations. Phosphorus loads delivered to the irrigated lands in the absence of the ROWQIP are referred to as baseline (BL) operations. The load (L) reduction produced by the change in canal operations is calculated by subtraction:

$$\textbf{Equation 2}: L\ Reduction_{\ in\ rivers} = \left(L_{Delivered} - L_{Runoff}\right)WQ - \left(L_{Delivered} - L_{Runoff}\right)BL$$

The Riverside Canal model uses a water-balance approach similar to the load balance (Equation 1), applied over the 31-mile long canal (Exhibit 7.2-2—Appendix 3). Because the phosphorus load is calculated from the flow rate and phosphorus concentration, defining both flow and concentration are key considerations for load reduction calculations. The model assumes both tributary flow and water quality remain the same under water-quality and baseline operations. Therefore, the load reductions are derived from changes in Boise River diversion rates.

7.2.1.1.3.1. Water-Quality Operations Flows

As stated previously, the load reductions for water-quality-focused canal operations are accomplished by prioritizing the use of high-nutrient agricultural and municipal drainage water. This is accomplished by minimizing the diversion of the comparatively higher-quality Boise River. In 2014, the Supervisory Control and Data Acquisition (SCADA) systems controlled the diversion throughout most of the irrigation season. The flow data collected at the Boise River diversion was, and will continue to be, used to model the flows (and concentrations) along the canal.

7.2.1.1.3.2. Baseline Operations Flows

As shown by Equation 2, defining BL operations is necessary to determine the amount of phosphorus load reduction resulting from the ROWQIP. A definition of the baseline diversion is the critical parameter because it determines the flow along the canal, which will then be used to determine phosphorus loads for the BL operations.

The ROWQIP is specifically designed to modify canal operations in a way that reduces phosphorus loading to the Snake and Boise rivers. However, the program does not include any actions to modify or redefine Riverside’s overall irrigation requirements or the volume of water diverted as currently specified by adjudicated water rights. Therefore, it is appropriate that the baseline relative to water diverted from the Boise River be Riverside’s legally established water rights, which total 271.5 cfs (IDWR 2013). Under Idaho law, the adjudication of these rights constitutes a judicial determination that the decreed amount of water was put to use and that the users have the right to continue to put those decreed rates to use. While actual diversion may vary among years and specific times within a given year from the water-right diversion rate, it is the rate allowed under law and therefore the most logical and legally defensible flow estimate for use in baseline calculations.

7.2.1.1.3.3. Water Quality

The phosphorus concentrations used to determine loads for both water-quality and baseline operations are the concentrations measured in water sources flowing into the Riverside Canal. These concentrations are measured for the primary sources during project operations, which are the Boise River, Indian Creek, and West End Drain. Because this project deals mainly with changes in the operation of the water delivery system, rather than on-farm or upstream practices that improve water quality, it is appropriate to incorporate any changes in phosphorus concentrations of inflowing water into the quantification of baseline conditions.

7.2.1.1.3.4. Agricultural Runoff

For purposes of estimating load reductions to the Boise and Snake rivers, the runoff load from agricultural land is assumed to remain unchanged. This assumption is considered conservative for a number of reasons detailed in Exhibit 7.2-2, Appendix 3, and includes the following:

1. Typically, more than 90% of phosphorus runoff from "clean-tilled row-crop" fields is in particulate form.

2. Soils typically have the capacity to retain a large percentage of the phosphorus applied.

3. The change in canal water quality anticipated for the canal is relatively small and represents less than 3% of the phosphorus needed to produce crops.

4. On-farm water quality and nutrient management has increased over the last 10 years (i.e., since the SR–HC TMDL was established) and will be an ongoing focus of future load reduction efforts.

7.2.1.1.4. Riverside Canal Modeled Load Reductions

To estimate the load reductions under water-quality operations, the Riverside Canal model was applied using data collected in 2014. The 2014 average modeled flows, concentrations, and loads for the parameters shown in Figure 7.2-2 and Equation 1 are given first to illustrate how data are used to calculate the TP load reductions. This is followed by a summary of total reductions for the 2014 irrigation season. More detailed information on modeling the daily average loads is presented in Exhibit 7.2-2, Appendix 3.

7.2.1.1.4.1 Simplified Average Load Reduction Calculations for 2014

A simplified presentation of the Riverside Canal model, which is based on the schematic diagram (Figure 7.2-2), is used to show how the TP load reduction under baseline and water-quality conditions in 2014 differ (Table 7.2-1). The measured tributary and delivered flows in 2014 are the same for both operations, while the flow diverted from the Boise River varies. For the water-quality operations, the diversion from the Boise River was minimized, while for the BL, the diversion flow is the adjudicated water right of 272 cfs. Because Boise River inflows vary between the 2 operational scenarios, the calculated spills back to the Boise and Snake rivers also vary between scenarios. The change in proportions of canal-source water produces the different TP concentrations for the water delivered. The concentrations of TP in source water (diversion and tributary) are assumed to remain constant under both operations.

Table 7.2-1
Example of load-reduction calculations based on 2014 average model results

	Total Phosphorus		
	Flow (cfs)	**Conc. (mg/L)**	**Load (lbs per day)**
2014 Operations			
Diversion	67	0.21	76
Tributary	276	0.61	906
Spill	100	0.52	279
Delivery	**242**	**0.54**	**703**
Baseline Operations			
Diversion	271	0.21	302
Tributary	276	0.61	906
Spill	305	0.41	679
Delivery	**242**	**0.41**	**529**
TP Reduction		**0.13**	**174**

The Riverside Canal model is used to calculate “comparable” concentrations for the water delivered under each of the operations. The change in concentration of the water delivered to irrigators, which is the primary goal of the ROWQIP, can be used directly to calculate the TP load reduction because water delivery is the same for both operations.

For comparison, the estimated potential load reduction for 2013 was 164 lbs per day with delivered flow of 215 cfs and change in concentration of 0.14 mg/L (Exhibit 7.2-2—Appendix 3). The 2013 load reduction is termed a “potential load reduction” because in the prior year canal operations were not directed toward “full time” water-quality improvements, while in 2014 water quality was the focus over the entire irrigation season.

7.2.1.1.4.2 Average Load Reductions for 2014

The total estimated phosphorus load reduction attributable to the ROWQIP in 2014 is 31,920 lbs. This represents the sum of the modeled daily change in phosphorus load in the Boise and Snake rivers that could occur under full implementation of the ROWQIP over a 183-day irrigation season.

7.2.1.1.5. Monitoring and Reporting

A detailed monitoring and reporting plan will be submitted to the ODEQ and IDEQ within 1 year of the new license issuance for the HCC. The monitoring and reporting plan will comply with all conditions and requirements contained in the CWA § 401 certifications issued by the ODEQ and IDEQ. The plan will be developed and incorporated into the ROWQIP to ensure a level of quality consistent with regional and national nutrient trading programs. Specifically, reports will be of sufficient quality to support the ODEQ and IDEQ’s determination of compliance with the HCC CWA § 401 certification requirements, as well as third-party verification, if required. The monitoring and reporting plan may be updated and modified over the course of the project based on technology advances. Any proposed changes will be identified in reports to the ODEQ and IDEQ and will be subject to their approval.

7.2.1.1.6. Implementation Timeline

IPC began its participation with Riverside to reduce phosphorus loading to the Boise and Snake rivers in 2010. Implementation of the project began in 2014. In 2014, IPC and Riverside signed a binding contract that identifies operational requirements for Riverside, and financial compensation by IPC to ensure the project is operated in a way that results in phosphorus load reductions. The contract and phosphorus reductions realized in 2014 provide certainty that IPC's Brownlee Reservoir DO load allocation can be met by the ROWQIP project. However, should future monitoring demonstrate adequate reductions are not being realized, the project has the potential to generate further reductions with more refined canal operations and the installation of additional automations. In addition, early implementation not only ensures that realization of benefits will begin immediately upon issuance of the HCC CWA § 401 certification, but also that long-term benefits can begin to accrue prior to § 401 issuance.

7.2.1.1.7. Adaptive Management

Riverside will manage inflows to the Riverside Canal by preferentially using sources of water that contain relatively high phosphorus levels for irrigation purposes, resulting in phosphorus reductions to the Boise and Snake rivers as well as Brownlee Reservoir. The operational plan outlined in this proposal is based on the current phosphorus conditions in each of the water sources. It is reasonable to assume that phosphorus levels in the source water being manipulated by the ROWQIP will change over the term of the HCC CWA § 401 certification. The overall goal of the project is to reduce phosphorus loading to the Snake and Boise rivers and Brownlee Reservoir though water management within Riverside's water-delivery system. Therefore, it is an inherent part of this plan that actual operations and the manipulation of inflowing source water could substantially change in the future should the phosphorus levels substantially change in source water. As the project evolves, more effort will be focused on reducing agricultural runoff and additional water improvements that could be added to the load reductions produced through the ROWQIP. Similar to any proposed changes in monitoring and reporting, any proposed changes to operations or other management actions to reduce phosphorus loads would be included in the reports and subject to approval by the ODEQ and IDEQ.

7.2.1.1.8. Planned Project Contract and Duration

The certainty and ability of IPC to use the ROWQIP for purposes of CWA § 401 certification will be defined and described through a legally binding contract between IPC and Riverside. The contract will provide certainty that IPC will have the right to claim the ROWQIP to mitigate for DO conditions in Brownlee Reservoir. The contract will include certainty that Riverside Irrigation District will give IPC preference in claiming ROWQIP as necessary to meet its Brownlee Reservoir DO mitigation requirement. This certainty will be explicitly identified in the contract to ensure it will remain in place for at least 5 years into the future.

7.2.2. Distributed Aeration Systems at Brownlee Powerhouse

IPC proposes upgrading 4 of the 5 turbines (i.e., units 1 through 4) at the Brownlee Powerhouse with distributed aeration systems. These systems would be operated within an adaptive management and monitoring framework to add as much additional oxygen to Brownlee outflow (and correspondingly Oxbow and Hells Canyon outflow, see Section 6.2 DO) as possible within the limitations of the current TDG criterion and considering Unit operation complications (e.g., vibrations, cavitation). IPC's proposed operation plan for this DO addition is to add DO during the low DO periods of the aquatic life (April 15–October 22) and salmonid spawning (October 23–April 14) periods. To incorporate the low DO time for both periods, IPC's proposed plan would focus on providing this benefit from July 1 to December 31 (Figure 6.2-22).

The proposed distributed aeration systems are being designed and built by Voith Hydro, Inc., (Voith Hydro). Distributed aeration systems are specifically designed to add air into the draft tube using air passages that lead to the trailing edge of the runner blades. Therefore, the systems planned for the Brownlee units will require complete replacement of the runners, along with other systems, for each unit. The operating principles are very similar to forced-air injection (i.e., blowers), except the runners allow for passive-air introduction without the need for blowers. This passive-air introduction is commonly referred to as auto-venting turbine aeration; however, the specific method of using the runner blades is referred to as distributed aeration. The efficiency losses for power production for auto-venting solutions are smaller than the blowers, and there is no need for a blower motor, associated power usage, or maintenance. Therefore, the operational costs of the proposed distributed aeration systems can be much less than forced-air injection. As with blower systems, there is the potential to elevate TDG with the distributed aeration. Because of the TDG limitation, blowers and distributed aeration will have nearly the same potential to increase DO. An analysis of potential TDG levels is included in this section. The configuration of units 1 through 4 at the Brownlee Powerhouse would allow distributed aeration installation. The configuration of unit 5 would not allow aerating runner installation unless a forced-air system was included.

Distributed aeration systems like those proposed at Brownlee Powerhouse are established technologies. Voith Hydro's research and development efforts have successfully developed and evaluated a variety of designs and methods for aeration. Voith Hydro's distributed aeration designs are in operation at the Tennessee Valley Authority's (TVA) Norris and Boone Powerhouses, Duke Power's Wateree plant, USACE's J. Strom Thurmond plant, Ameren's Osage plant, and Exelon's Conowingo plants.

7.2.2.2. Distributed Aeration Performance Modeling

IPC retained Voith Hydro, the manufacturer of the distributed aeration systems for Brownlee Powerhouse, to conduct a numerical modeling study to evaluate the potential DO uptake and resulting TDG levels associated with the operation of distributed aeration at Brownlee Powerhouse. The DO uptake and resulting TDG levels were estimated using a discrete bubble model methodology with Brownlee turbine draft tube geometry coupled with results from a Computational Fluid Dynamic (CFD) model to predict airflow rates through the system and into the water. The discrete bubble modeling incorporated the following variables that will control the overall DO benefit and corresponding TDG levels from distributed aeration at Brownlee Powerhouse: individual unit discharge, tailrace water-surface elevation (tailwater elevation), headwater surface elevation, water temperature, incoming DO concentration, incoming DN concentration, airflow rate (determined from the CFD model), and the size of air bubbles emitted. In the distributed aeration systems, the airflow rate will not only change naturally along with unit discharge but also with a manual adjustment to the air intake valves. In the modeling study, no manual adjustment was assumed, so the airflow produced by a given discharge represents the adjustable valves completely open.

For the discrete bubble (i.e., DO uptake) modeling, the incoming temperature was set to 23°C. This is conservative, meaning the modeled DO uptake may be biased low, because DO uptake will be less at higher temperatures due to DO saturation levels being lower. Incoming DO was set to 2 mg/L and 0 mg/L for 2 sets of scenarios. For each set of scenarios, 3 different tailwater elevations were used: 1,801 (minimum); 1,805 (normal average); and 1,808 feet (maximum). These tailwater settings were selected to capture the range of potential operating conditions, with 1,805 feet being the midpoint and most frequently occurring. Unit discharge was modeled at 7 different points: 3,000; 3,300; 4,200; 5,000; 5,200; 5,430; and 5,673 cfs (Exhibit 7.2-3). Net head (headwater surface elevation) was also varied among the scenarios to capture the range of operating conditions; however, net head alone caused very little (e.g., 0.1 mg/L) variation in DO uptake. Therefore, DO uptake modeling for only 1 net head setting is summarized here.

The results of the DO uptake modeling show that during periods of high water temperature (i.e., 23°C) and low incoming DO (i.e., 2 mg/L or 0 mg/L), the uptake from aerating runners could range from 2.5 to over 4 mg/L (Figure 7.2-3). The variability in uptake at any given turbine discharge setting is caused from both the incoming DO level and tailwater elevation. Changing tailwater elevation causes pressure variation through the system that drives airflow rates into the blades. Deeper tailwater (i.e., higher elevations) also provides more pressure and contact time for oxygen transfer from bubbles into the water in the draft tube and tailrace. While the tailwater elevation does cause variability in DO uptake, the range of tailwater elevation used for the modeling captures the maximum and minimum, which are expected to occur infrequently. Therefore, for this analysis the results for the average tailwater elevation (i.e., 1,805 feet) are of primary interest. Under optimal turbine flow (i.e., highest efficiency for power output, approximately 5,000 cfs), an incoming DO of 2 mg/L, and an average tailwater elevation (i.e., 1,805 feet), the modeling showed a DO uptake of 3.1 mg/L (Figure 7.2-4). A higher DO uptake was seen with lower incoming DO where optimal turbine flow, incoming DO of 0 mg/L, and an average tailwater showed uptake of 3.6 mg/L.

Voith Hydro’s numerical modeling resulted in estimates of DO uptake with the maximum anticipated airflow (based on the CFD model results). Airflow rates will be adjustable following implementation, and a reduction in airflow may be need based on testing, adaptive management and TDG concerns (see Section 7.2.2.3. Anticipated Effects of Distributed Aeration) In addition, there are potential airflow losses that may be incurred with the installation of additional infrastructure in the air supply piping (e.g., safety valves) that is not accounted for in the modeling.

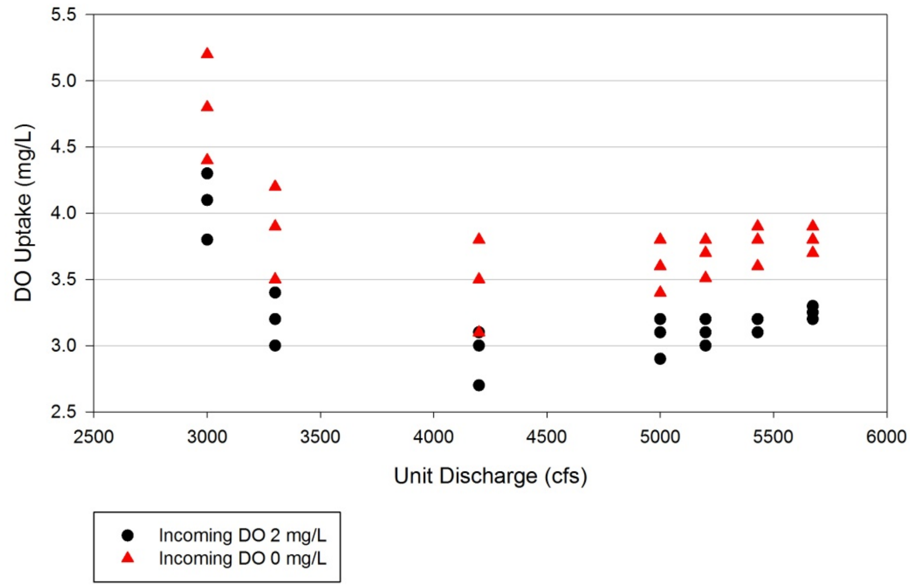


Figure 7.2-3
DO uptake simulated by Voith Hydro over a range of discharge and tailwater elevations (i.e., 1,801; 1,805; and 1,808 feet) for 1 of Brownlee Powerhouse units 1 through 4. Model settings included an incoming temperature of 23°C and incoming DO of 2 and 0 mg/L. The DO uptake was modeled assuming a maximum airflow rate at the various discharges and no airflow adjustment. An adjustment will be possible following implementation.

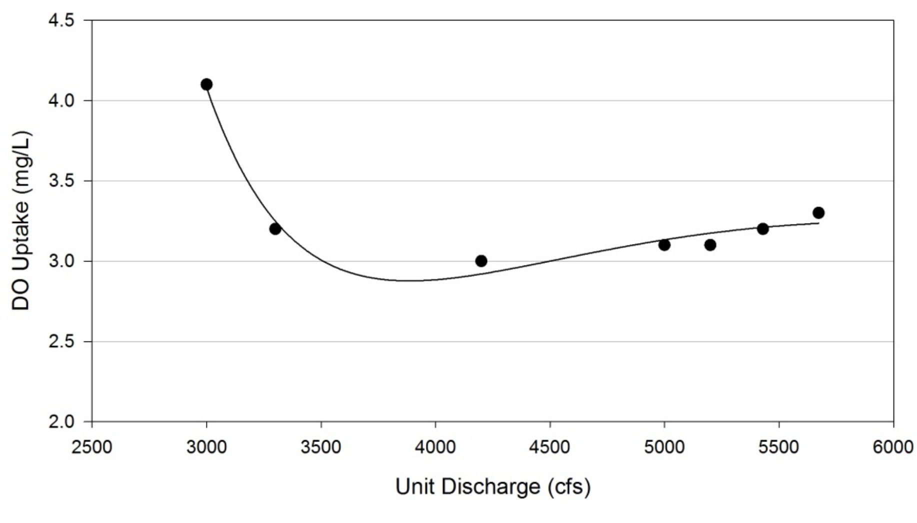


Figure 7.2-4
DO uptake simulated by Voith Hydro over a range of discharge for 1 of Brownlee Powerhouse units 1 through 4 with an incoming temperature of 23°C, incoming DO of 2 mg/L, and average tailwater elevation of 1,805 feet. The DO uptake was modeled assuming a maximum airflow rate at the various discharges and no airflow adjustment. An adjustment will be possible following implementation.

Voith Hydro conducted a separate series of model runs using the discrete bubble model to evaluate potential TDG increases. This series consisted of runs with variable incoming DO, tailwater elevation, unit discharge, and DN concentrations. For the model runs summarized here, the incoming DN was assumed to be 18 to 20 mg/L based on calculations that produced incoming TDG levels of 95 to 105% saturation with DO of 2 mg/L and no aeration. All scenarios used an incoming temperature of 20°C for the TDG analysis. Similar to the DO uptake modeling, all TDG scenarios included the maximum anticipated airflow through the unit (based on CFD model results). The TDG modeling results show that with these settings, the TDG levels could be increased 11 to 27% over incoming TDG levels (Figure 7.2-5). The variability in modeled TDG increases at a given discharge setting is caused by different tailwater and DN settings. The highest increases were seen with an incoming DN of 18 mg/L (corresponding to incoming TDG of 95%). At the average tailwater elevation (i.e., 1,805 feet) with DN of 18 mg/L, TDG increases ranged from 18 to 25%. TDG increases were directly related to DO uptake (Figure 7.2-6). As with the DO uptake modeling, the TDG increases are without adjustment of airflow. Mixing of the aerated discharges from units 1 through 4 with the non-aerated discharge from Unit 5 will also lower the overall TDG increase from aeration in the river downstream.

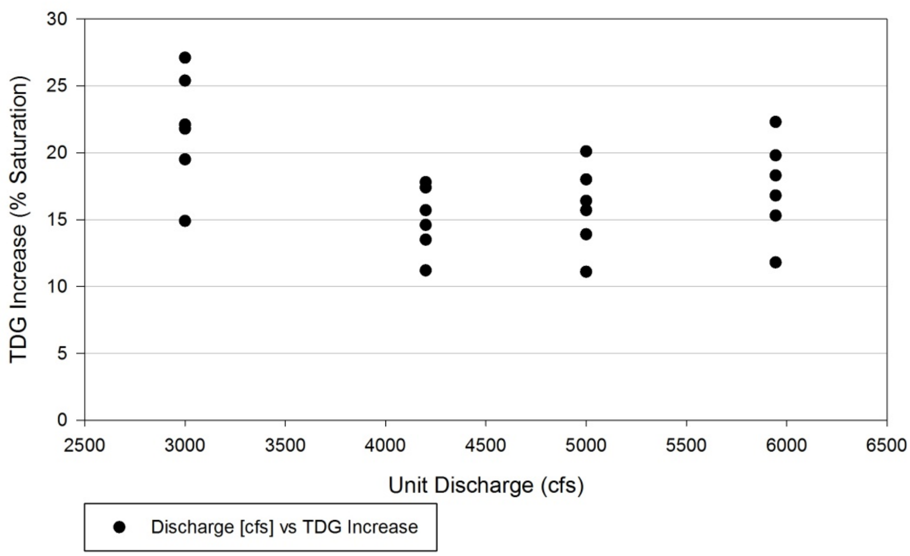


Figure 7.2-5
TDG increases simulated by Voith Hydro over a range of discharge and tailwater elevations (i.e., 1,801; 1,805; and 1,808 feet) for 1 of Brownlee Powerhouse units 1 through 4. Other model settings included an incoming temperature of 20°C, incoming DO of 2 mg/L, and incoming DN of 18 or 20 mg/L (which equated to incoming TDG of 95 or 105%, respectively). The TDG increases were modeled assuming a maximum airflow rate at the various discharges and no airflow adjustment. An adjustment will be possible following implementation.

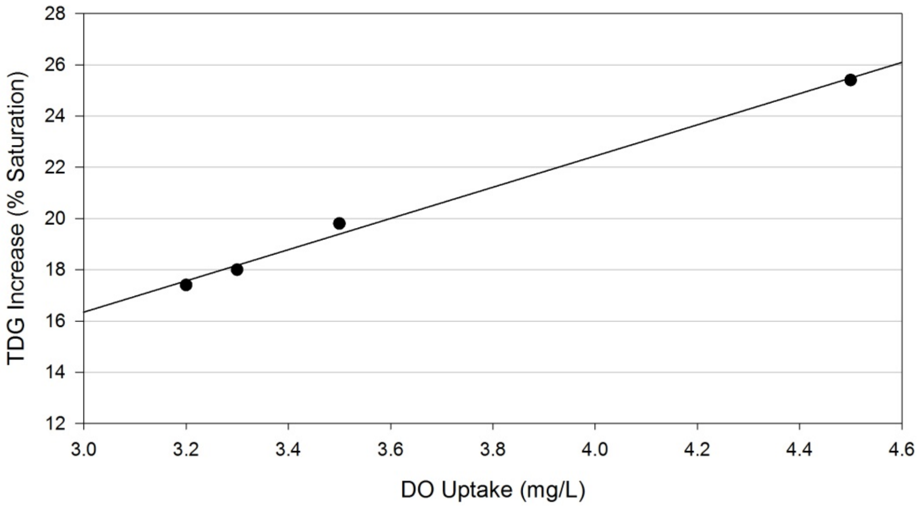


Figure 7.2-6
TDG increases related to DO uptake from the Voith Hydro modeling for the average tailwater elevation (i.e., 1,805 feet), incoming temperature of 20°C, incoming DO of 2 mg/L, and incoming DN of 18 mg/L (which equated to incoming TDG of 95%).

7.2.2.3. Anticipated Effects of Distributed Aeration

The Voith Hydro modeling described above was used to show the general potential of the planned distributed aeration systems at Brownlee Powerhouse. Potential TDG increases were also evaluated. A number of assumptions were needed to accomplish the modeling conducted by Voith Hydro. Many of the parameters known to be very dynamic in the field such as incoming DO, incoming TDG, incoming temperature and tailwater elevation were necessarily set at constant values. As a result, the Voith Hydro modeling provides detailed information as a starting point to examine the potential and limitations of the distributed aeration systems. However, the actual effects and limitations of the distributed aeration systems cannot be known until installed, tested, operated and monitored. An adaptive management plan is outlined below including testing and monitoring as discussed in Section 7.2.2.4. Implementation Schedule and Monitoring Plan for Distributed Aeration Systems with the goal of providing as much aeration as possible within the limits of the current TDG criterion.

As mentioned previously, there are 5 units at Brownlee Powerhouse. Units 1 through 4 are all the same type of unit and are smaller (i.e., hydraulic capacity of approximately 5,500 cfs) than Unit 5 (i.e., hydraulic capacity of approximately 12,000 cfs). Unit operations at Brownlee are dependent on many factors (e.g., daily and seasonal load following, spinning reserves, system stability, and voltage support and water management), which result in multiple combinations of various units in operation over the course of a day (Figure 7.2-7).

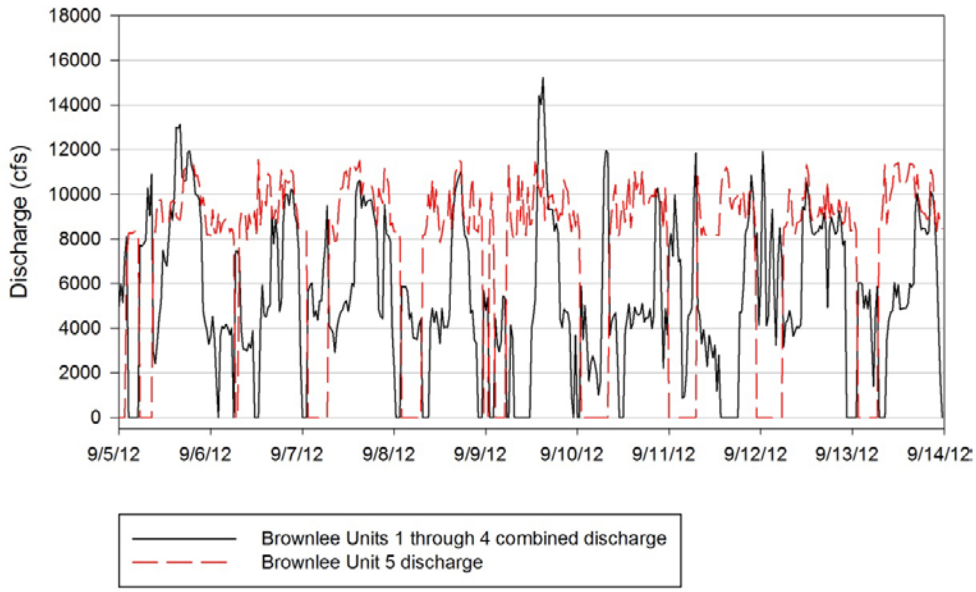


Figure 7.2-7
Brownlee Powerhouse units 1 through 4 combined and Unit 5 discharge over an 8-day period in September 2012. Hydraulic capacity of units 1 through 4 is approximately 5,500 cfs each, while Unit 5 hydraulic capacity is approximately 12,000 cfs.

IPC’s distributed aeration proposal is planned to aerate the discharge from units 1 through 4 and not Unit 5. This means that 3 aeration and mixing scenarios will occur. When units 1 through 4 (in any combination) are operating alone, additional oxygen would be added to the entire discharge. At times when all units are operating, the additional DO added to discharge from units 1 through 4 would be mixing with the non-aerated (i.e., no additional oxygen added) discharge from Unit 5. Finally, at times when only Unit 5 is operating, there would be no additional oxygen added to the discharge. This condition when Unit 5 is operating alone historically occurs relatively infrequently through the course of a day and not for an entire day or multiple days in a row (figures 7.2-7 and 7.2-8). When Unit 5 is operating it is typically in the range of 9,000 to 12,000 cfs. The Voith Hydro modeling combined with some simple mixing scenarios shows that during times when Unit 5 is not operating, a mixed condition downstream in Oxbow could be highly aerated (i.e., 3 mg/L DO Uptake) and TDG may exceed 110% (Figure 7.2-9). When Unit 5 is operating, a mixed condition downstream in Oxbow could be aerated with an additional 1 to 2 mg/L and TDG may exceed 110% depending on how many of units 1 through 4 are operating. All or any of the example combinations shown in Figure 7.2-9 can occur at the Brownlee Powerhouse over the course of a day on a very short time step (hourly). Given the variability in field conditions (e.g., incoming DO, TDG, and temperature, tailwater elevation, unit operations) and the assumptions in the Voith Hydro modeling (e.g., incoming DO 2 mg/L and temperature 23°C) the simple mixing scenario only shows an example of the potential of the distributed aeration systems. As systems are installed, tested and monitored the air flow can be manually adjusted to meet the overall goal of aerating as much as practical within the limits of the current TDG criterion.

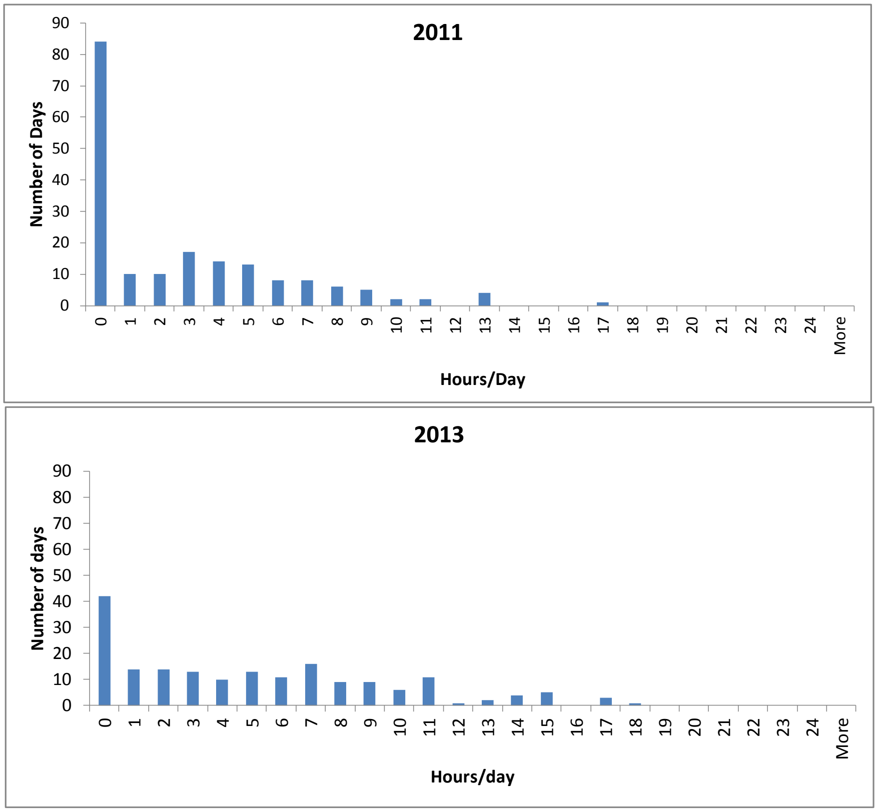


Figure 7.2-8
Frequency distribution showing how often Brownlee Powerhouse Unit 5 is operating by itself over the July 1 through December 31 period in 2011 (higher water year) and 2013 (lower water year)

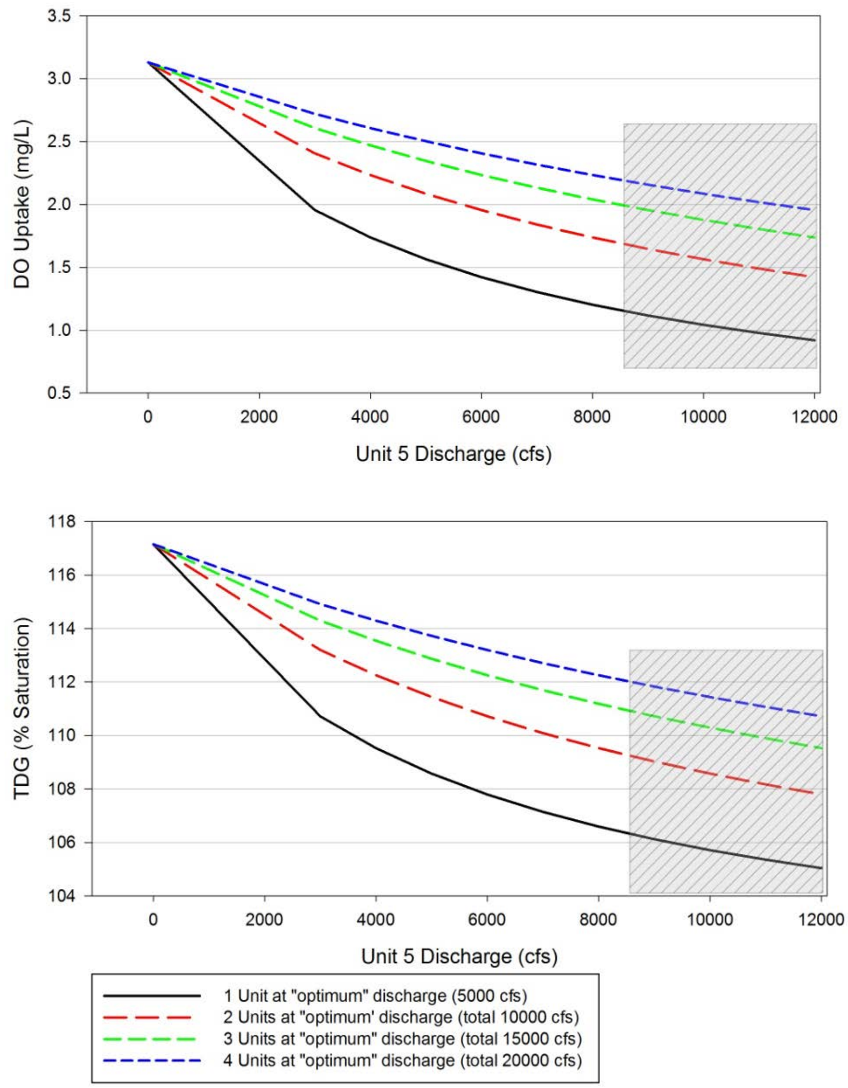


Figure 7.2-9
Simple mixing scenarios combining the results of Voith Hydro's numerical modeling study with optimum ranges for units 1 through 4 and unit 5 (shaded box shows typical discharge range of unit 5 when it is operating). These results represent a well mixed downstream condition under the initial incoming conditions of DO, TDG, temperature and tailwater elevation as described in the Voith Hydro modeling

7.2.2.4. Implementation Schedule and Monitoring Plan for Distributed Aeration Systems

Planning, contracting, and modeling phases of the distributed aeration system installation project are completed, and detailed schedules are continually being developed and updated. The runner fabrication by Voith Hydro and the installation at Brownlee Powerhouse are large efforts that will require each unit to be taken off-line sequentially. Multiple units cannot be off-line at the same time. The detailed schedule currently includes the following milestones:

- Design engineering, physical modeling, and materials acquisition—2013
- Unit 1 runner fabrication—2014–2015

- Unit 1 runner delivery to site—winter 2015
- Unit 1 installation complete—summer 2016
- Unit 2 installation complete—summer 2017
- Unit 3 installation complete—summer 2018
- Unit 4 installation complete—summer 2019

IPC will work with the ODEQ and IDEQ as part of the § 401 certification to develop a monitoring and adaptive management plan for the distributed aeration systems. The overall outline of this plan includes a testing phase and compliance monitoring phase. The goal of the testing phase will be to verify the relationships and assumptions developed through Voith Hydro's numerical modeling and test the effectiveness of the systems. The goal of the compliance monitoring phase will be to monitor and report DO and TDG at a representative downstream mixed location and at a frequency to be determined during the adaptive management process with the DEQs.

Testing will be conducted throughout the sequential installation of each new system on units 1 through 4. The complete installation of all 4 units is planned to be completed in summer 2019, which is prior to the anticipated new FERC license issuance date and testing will be completed by the end of 2020. Data will be collected during the testing relative to the key numerical modeling assumptions, which include the following:

- Unit discharge
- Tailwater elevation
- Airflow
- Temperature, DO, and TDG discharge from the unit
- Temperature DO, and TDG at downstream locations (e.g. Oxbow outflow and Hells Canyon outflow)

Annual reports will be presented to and discussed with the DEQs. These reports will include:

- Updates on the implementation schedule progress
- Results of the testing phase including:
    - Conclusions as to whether or not the installed units appear to be meeting expectations.
    - Recommendation on long-term downstream monitoring locations and frequency
- Discussion of issues or concerns and recommendations on adaptive management steps.

7.2.2.5. Adaptive Management for the Distributed Aeration Systems

Based on the analysis conducted to date related to the distributed aeration systems, there is a very high level of assurance that the systems will be capable of offsetting the 0.2 mg/L negative effect of Oxbow and Hells Canyon reservoirs on outflow DO. However, since IPC is proposing to operate the systems to maximize the aeration potential, adaptive management and testing will be helpful in defining the specific operation of the systems. IPC will monitor and collect relevant data and information not only through the testing phase of the distributed aeration systems, but as the measures proceed through the licensing term. The data and information will be used to develop and implement accepted adaptive management principles to ensure that the measures adequately IPC's compliance obligations.

Further, in the unlikely situation that issues are identified through the testing phase, or thereafter, relative to future compliance, IPC will develop and consider alternatives and discuss them with the DEQs. The need to identify and consider these issues as implementation of the measures proceed, arises from the ubiquitous concern of applying results of numerical models to dynamic in-field installations. Although the modeling conducted by Voith Hydro and the application of the results to historical IPC data represents the best information and techniques at this time, there is still a need to evaluate these measures as they are implemented. Among the issues that could potentially arise, and potential adaptive management measures to address them, are the following:

- If an issue concerning the ability to meet the anticipated efficiency of DO uptake without exceeding the TDG criteria of 110% in a mixed downstream condition arises IPC could:
    - Implement biological monitoring to determine if effects are being seen from any of TDG increases from the aeration systems.
    - Explore the feasibility of applying for a TDG standard modification.
- If an issue concerning a loss in electric generation efficiency from aeration that is larger than expected or other unanticipated issues with unit performance or operation arises IPC could:
    - Explore the feasibility of a blower designed for aeration on Unit 5 to reduce aeration in units 1 through 4.
    - Explore the feasibility of aeration systems at Oxbow and/or Hells Canyon powerhouses to reduce the aeration needed at Brownlee units 1 through 4.

7.2.3. Destratification Measure for the Oxbow Bypass

IPC proposes to install and operate a destratification system in the Oxbow Bypass. This system would be located in the deep pool just upstream of the Indian Creek confluence. The pool is located in a section of the Oxbow Bypass inaccessible by road (Figure 7.2-10). Thermal stratification in the deep pool causes anoxic conditions to develop in the deeper water. Mixing to prevent anoxic conditions will provide improved habitat for aquatic life. The goal of this measure is to introduce oxygen using diffused air bubbles to prevent the development of anoxic conditions in the deep pool.

7.2.3.1. Description

Destratification systems are common throughout the U.S., and several manufacturers offer various configurations and models. At least 2 manufacturers offer designs that are all-inclusive, self-contained mixing units (water is mixed using a propeller in the water column) powered by wind and/or solar energy. These units are anchored in the water over the location to be mixed. There is a risk of damage to these during high flows through the bypass during periodic spill events if they are not removed from the water. The units are large, heavy, and awkward to move, making temporary removal difficult.

Several manufacturers offer systems that use an air compressor stationed on the shore that pumps air through a pipe to bubble diffusers anchored on the channel bottom. As the bubbles rise through the water column, they entrain water and lift it to a higher elevation. These types of systems are more suitable for the deep pool because they would be somewhat resistant to high spill flows. Also, if the piping or diffusers are damaged during spill, replacement efforts and expenses would be lower.

7.2.3.1.1. Proposed Design

IPC contracted with Mobley Engineering, Inc., to determine the optimal flow rate needed to keep the pool mixed throughout the summer. Knowing the flow rate helps determine the size of the compressor and diffuser required. Based on an estimation of the deep-pool volume, a flow rate of approximately 6 cfs is needed to exchange all of the water in the pool once every 8 hours. With this flow rate, all the water volume within the pool would be exchanged approximately 3 times a day. IPC believes this will be a sufficient flow rate to prevent thermal stratification.

IPC will develop a final design of a compressor system appropriate to prevent anoxia. The final design will include siting, power supply, and other necessary components. The operational plan will depend on the final design; however, the goal of the plan will be to operate the system as needed to prevent anoxia.

7.2.3.1.2. Implementation Schedule and Monitoring Plan

The final design and permitting process for the Oxbow Bypass destratification system will begin in the first year following new license issuance.

The installation of the Oxbow Bypass deep-pool destratification system will be completed, and operation will begin within 2 years after new license issuance, provided the required permits and approvals can be obtained in this time period.

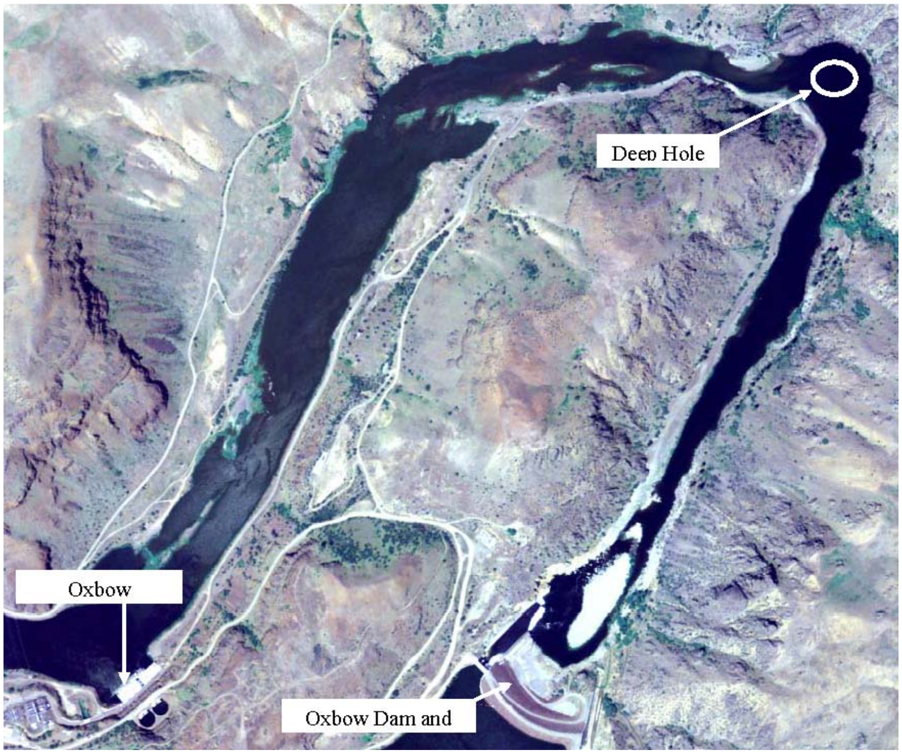


Figure 7.2-10
Aerial photograph and description of the Oxbow Bypass reach and deep pool

7.2.4. System-Wide DO Monitoring Proposal

In addition to the specific monitoring proposals relative to the ROWQIP (Section 7.2.1.1.5. Monitoring and Reporting) and distributed aeration systems (Section 7.2.2.4. Implementation Schedule and Monitoring Plan for Distributed Aeration Systems), IPC proposes long-term DO monitoring at Brownlee Reservoir inflow and Hells Canyon outflow for the term of the new FERC license. Specific monitoring plans for these 2 locations will be developed within 1 year of issuance of the new FERC license.

7.3. TDG Adaptive Management Plan

The TDG adaptive management plan includes PME measures that research shows to be the best available technologies to reduce TDG levels. These include 1) the continued preferential spilling of water through the Brownlee Dam upper spill gates as an early implementation measure, 2) the evaluation of TDG reduction structures at Oxbow Dam as an early implementation measure, 3) the installation of HCD sluiceway flow deflectors, 4) the installation of Brownlee Dam spillway flow deflectors, and 5) the installation of a spillway flow deflector at Oxbow Dam.

IPC will monitor TDG levels below spillways and at other locations throughout the HCC and Snake River downstream, as needed, for PME measure effectiveness and compliance relative to the criterion. The specific locations of data collection will be determined in consultation with the

ODEQ and IDEQ (see Section 7.3.4. TDG Monitoring). If monitoring indicates the PME measures fail to meet the TDG criterion and protect aquatic life, IPC will adaptively manage TDG in the HCC through the evaluation and implementation of additional PME measures designed to further reduce TDG levels. IPC concurs with the IDEQ and ODEQ (2004) that the TDG criterion is conservative for the protection of aquatic life and, therefore, the load allocation has an implicit margin of safety.

7.3.1. TDG Proposed Measures

7.3.1.1. Preferential Brownlee Dam Upper Gate Spill

IPC proposes to continue the current practice of preferentially spilling water from the Brownlee Dam upper spillway gates. IPC proposes this PME measure as part of the early implementation of CWA § 401 certification.

7.3.1.2. HCD Sluiceway Flow Deflectors

7.3.1.2.1. Proposed Action

IPC proposes to install HCD sluiceway flow deflectors to address the SR–HC TMDL TDG load allocation at HCD and protect aquatic life. Implementation will occur consistent with the schedule in the new FERC HCC license. This schedule would accommodate FERC's required design review process and permitting requirements. It is expected these requirements could be completed within 2 years of the new license issuance. The construction and installation of the flow deflectors would be completed during the following 2 years.

7.3.1.2.2. Proposed Design

The Iowa Institute of Hydraulic Research[49] (IIHR), under contract with IPC, investigated the applicability of flow deflectors at HCD to reduce TDG levels. The distinctive geometry of HCD presents challenges in developing flow deflectors to reduce TDG levels because of the existing upper-nappe deflectors, relatively large head, deep and short stilling basin, and high unit flow (Exhibit 7.3-1). Specifically, flows originating from the upper spillway gates are deflected away from the concrete spillway surface by the nappe deflectors, and the flow becomes a nearly unattached, free-falling jet. Very large deflectors for the upper spillway gates would be needed because the falling jet would overshoot smaller deflectors. When large deflectors were tested in a 1:48-scale, 3-dimensional physical model (figures 7.3-1 and 7.3-2), the deflected flows impacted the riverbed downstream of the stilling basin, which could compromise dam safety during the passage of large spillway flows.

[49] The IIHR recently changed its name. Its current name is the Iowa Institute of Hydraulic Research—Hydroscience and Engineering.

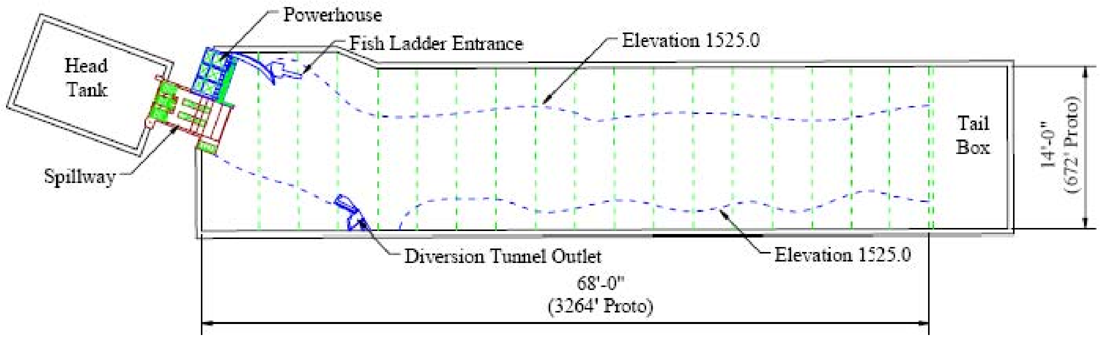


Figure 7.3-1
Plan view of the 1:48-scale, 3-dimensional HCD physical model

Figure 7.3-2
Photograph of the 1:48-scale, 3-dimensional HCD physical model

The unique geometry of HCD favors the implementation of flow deflectors in the 2 lower-level sluiceways. The concept of flow-deflector design is to favor a flow regime that minimizes air entrainment at depth. As such, flow-deflector elevation is critical. The flow-deflector elevation was determined by analyzing tailwater curves for Snake River flow at or below a design discharge of 60,000 cfs[50] (Exhibit 7.3-1). This accounts for most of the flows recorded from 1968 through 2003 (Figure 6.3-8). The design must remain below the tailwater elevation to

[50] The HCD design discharge of 60,000 cfs was based on 3 powerhouse units, each with a hydraulic capacity of 10,000 cfs, and 2 sluiceway bays, each with a hydraulic capacity of 15,000 cfs.

prevent vented surface or plunging flows from occurring, which tend to allow air bubbles to penetrate to depth while remaining high enough to keep the performance within the surface-jet flow regime (Figure 7.3-3). The flow-deflector design was qualitatively optimized using a 1:48-scale, 3-dimensional physical model (figures 7.3-1 and 7.3-2). The design consists of a 16-foot deflector at an elevation of 1,468 feet msl with a 5° lip angle (Figure 7.3-4). This design resulted in a surface jet up to total Snake River flow of 60,000 cfs. More detail on the HCD sluiceway flow-deflector design is available in Exhibit 7.3-1.

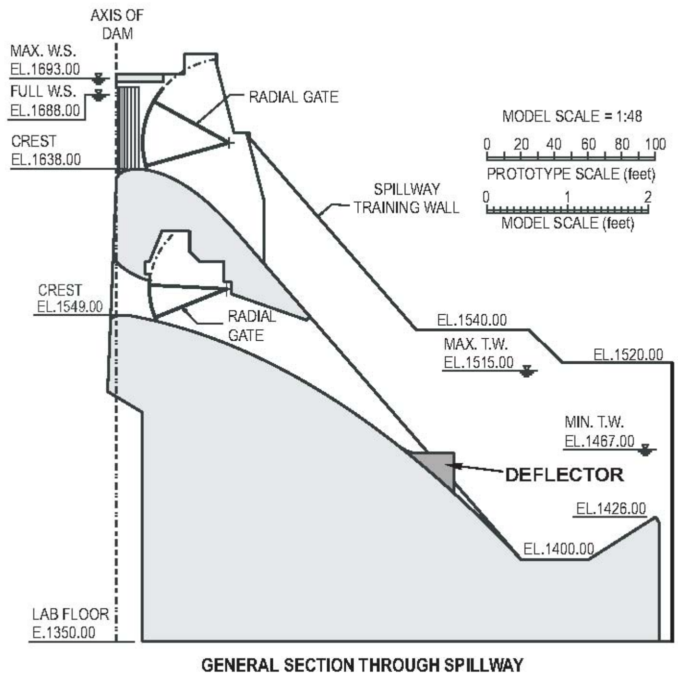


Figure 7.3-3
Sectional view of the HCD model constructed by the IIHR showing the general location of sluiceway flow deflectors

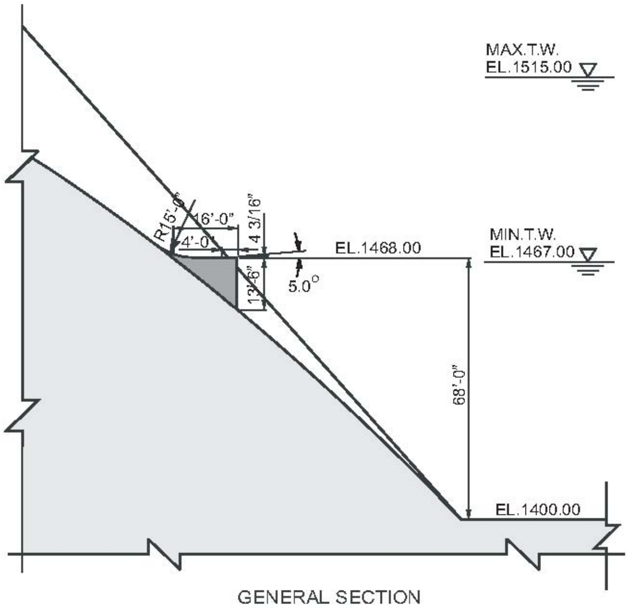


Figure 7.3-4
General view of the HCD sluiceway flow-deflector configuration developed by the IIHR

The IIHR investigated the deflector air entrainment performance and tailrace erosion potential of the qualitatively designed sluiceway flow deflectors. The 3-dimensional physical modeling revealed that the deflector air entrainment performance was preserved when the tailrace bathymetry was incorporated. The sluiceway flow-deflector design did not increase the erosion potential at the probable maximum flood (PMF) design level of 300,000 cfs Snake River flow when compared to spill operations without deflectors. In fact, the 3-dimensional physical model predicted a decrease in scour depths under the design discharge of 60,000 cfs with deflectors installed. More detail on the HCD sluiceway flow-deflector design downstream hydrodynamics and erosion potential is available in Exhibit 7.3-2.

The sluiceway flow-deflector design was qualitatively optimized to be effective at reducing TDG levels at a design flow of 60,000 cfs. Approximately 1% of flows are greater than 60,000 cfs and less than the 7Q10 average flood flow of 71,498 cfs. There remained uncertainty as to the performance of the qualitatively designed sluiceway flow deflector and how a quantitatively optimized flow-deflector design would perform across these higher but very infrequent flows. To address this uncertainty, the IIHR quantitatively optimized the final HCD sluiceway flow-deflector design based on computations using a 3-dimensional finite element CFD model (Exhibit 7.3-3). The CFD model quantitatively evaluates TDG levels based on dam geometry, bathymetry, gas-bubble diffusivity, and fluid dynamics. The IIHR evaluated 3 additional geometries with a modified elevation, length, and transition radius for 2 flows representing potential operations: 25,000 cfs and 45,000 cfs[51]. This evaluation confirmed the qualitatively

[51] The discharge rates included 7,500 cfs through each of 2 sluiceway bays, with a hydraulic capacity of 15,000 cfs. Therefore, the 25,000 cfs included 1 powerhouse unit, and the 45,000 cfs flow represented full generation capacity.

designed sluiceway flow-deflector design performed better to reduce TDG and had less impact on the tailrace flow pattern. This design was then evaluated at 3 flows inclusive of the 7Q10 average flood flow. The 7Q10 average flood flow requires any flow greater than the combined powerhouse and sluiceway hydraulic capacity of 60,000 cfs to be spilled through the upper spillway gates, plunging downstream of the stilling basin with appreciable TDG production. When large deflectors capable of accommodating spill from the upper spillway gates were tested in a 1:48-scale, 3-dimensional physical model (Exhibit 7.3-2), the deflected flows impacted the riverbed downstream of the stilling basin, which could compromise dam safety during the passage of large spillway flows. The HCD sluiceway flow deflectors still reduced TDG production by approximately 10% at the 7Q10 average flood flow. More detail on the HCD sluiceway flow-deflector design performance and TDG production is available in Exhibit 7.3-3.

7.3.1.3. Brownlee Dam Spillway Flow Deflectors

7.3.1.3.1. Proposed Action

IPC proposes to install Brownlee Dam spillway flow deflectors to address the SR–HC TMDL TDG load allocation at Brownlee Dam and protect aquatic life. Implementation will occur consistent with the schedule in the new FERC HCC license. This schedule will accommodate FERC's required design review process and permitting requirements. It is expected that construction and installation could be completed within 2 years of construction of the HCD sluiceway flow deflectors. It may be necessary to monitor the effectiveness of the installed HCD sluiceway flow deflectors before developing a CFD model to quantitatively optimize the Brownlee Dam spillway flow-deflector final design. Any delay in the schedule will be vetted with the ODEQ and IDEQ for their approval and submitted to FERC for approval. Until the deflectors are installed, IPC will preferentially spill from the Brownlee Dam upper spillway gates as an early implementation PME measure.

7.3.1.3.2. Proposed Design

Similar to the HCD deflectors, the IIHR, under contract with IPC, investigated the applicability of flow deflectors at Brownlee Dam to reduce TDG levels (exhibits 7.3-4 and 7.3-5). IPC identified, prior to physical modeling, a concern relative to downstream scour following the installation of deflectors. This concern was not only for dam safety but was also identified as having the potential to disrupt power distribution and public transportation. As such, the Brownlee Dam 1:48-scale, 3-dimensional model (figures 7.3-5 and 7.3-6) included not only the spillway section of the dam but also the powerhouse units, training walls, earthen embankments, and 2,900 prototype feet of downstream tailrace bathymetry. The latter 2 elements were included to evaluate scour resulting from a geometric spillway change. While scaled laboratory model tests do not necessarily replicate field results, the comparison was useful in evaluating either a worsening or lessening of scour effects.

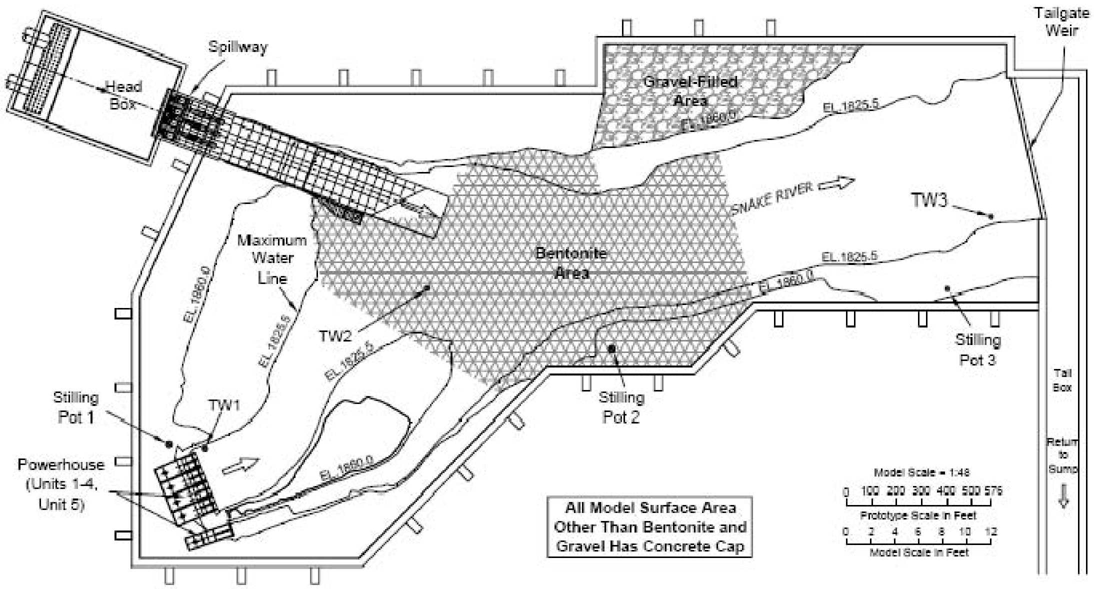


Figure 7.3-5
Plan view of the 1:48-scale, 3-dimensional Brownlee Dam physical model (reproduced from Exhibit 7.3-5)

Figure 7.3-6
Photograph of the 1:48-scale, 3-dimensional Brownlee Dam physical model

Flow-deflector elevation is also critical to the Brownlee Dam deflector design.
The Brownlee Dam spillway flow-deflector elevation was determined by analyzing tailwater curves for the Snake River. The elevation was determined based on tailwater flow up to the

7Q10 average flood flow of 67,898 cfs. The qualitatively optimized Brownlee Dam spillway flow deflectors resulted in an observed skimming surface-jet flow regime. The flow-deflector design consists of an 18-foot-long deflector at an elevation of 1,800 feet msl (Figure 7.3-7). More detail on the design of Brownlee Dam spillway flow deflectors is available in Exhibit 7.3-4. Erosion tests were performed with and without the proposed deflector design affixed to the 3-dimensional model. Each test was run with 48 hours of continuous model operation at both the 7Q10 average flood flow and the PMF. No scour occurred anywhere in the erodible materials at the 7Q10 average flood flow (Exhibit 7.3-4). Significant scour was observed in the erodible materials downstream of the spillway, as well as the formation of gravel bars in the tailrace at the PMF, both with and without the proposed deflector design affixed to the model. The model indicates erosion due to sustained PMF causes tremendous erosion downstream of the Brownlee Dam spillway with or without deflectors. During the PMF, the deflectors are overridden and the spillway jet resubmerges, dissipating energy in the stilling basin. The deflector appeared to cause no significant difference in tailrace erosion and does not significantly affect scour downstream of the spillway at the PMF. More detail on the erosion potential of Brownlee Dam spillway flow deflectors is available in Exhibit 7.3-5.

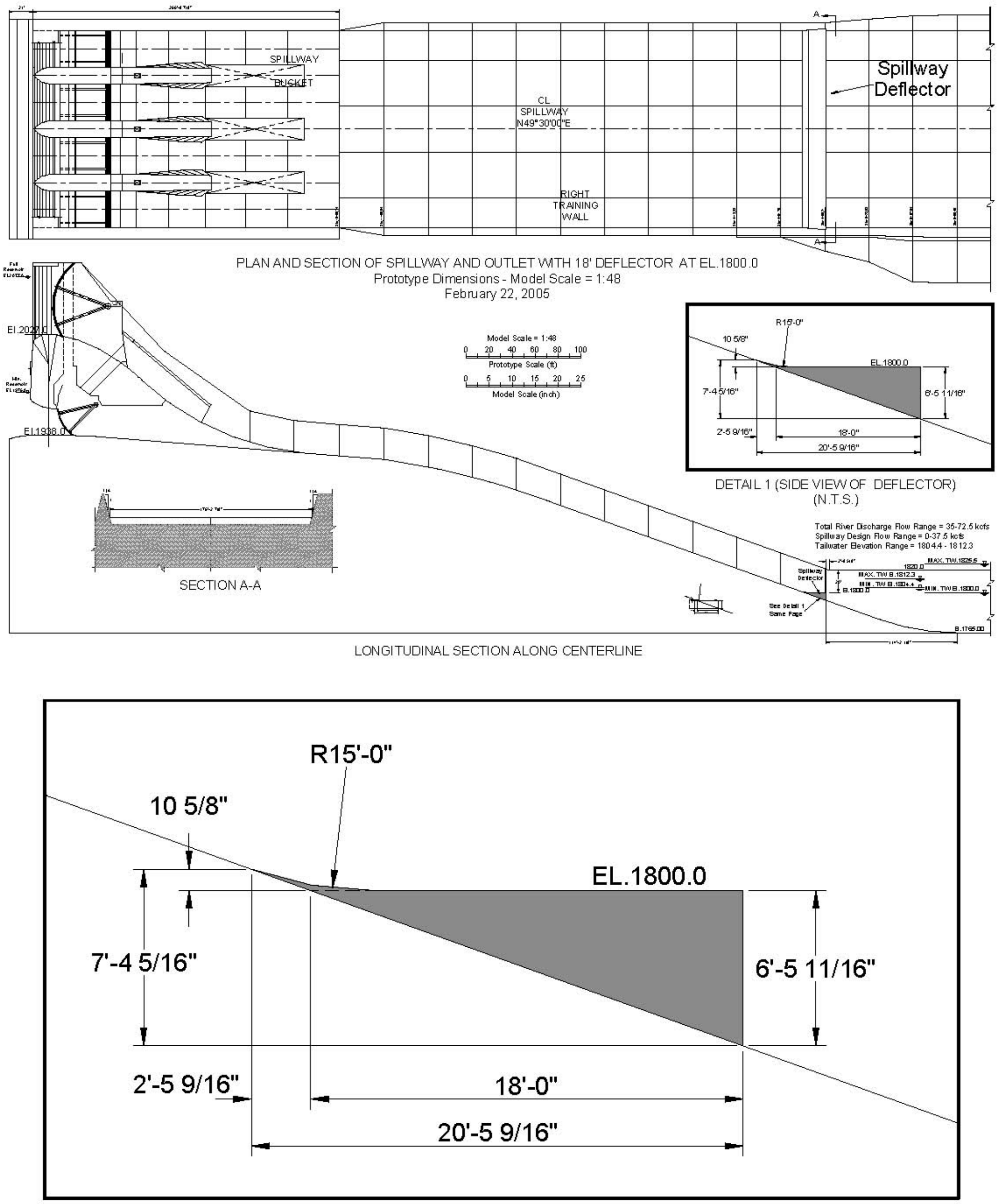


Figure 7.3-7
Plan and sectional view showing the general location of the Brownlee Dam spillway flow deflectors and a detailed sectional view drawing of the proposed design (reproduced from Exhibit 7.3-4)

The Brownlee Dam spillway flow-deflector design was qualitatively optimized to be effective at reducing TDG levels at the 7Q10 average flood flow. IPC proposes the final flow-deflector design to be quantitatively optimized and mathematically evaluated to the 7Q10 average flood flow based on computations using a CFD model and information gained from applying a similar model to optimize deflector design at HCD (Exhibit 7.3-3).

7.3.1.4. Oxbow Dam Spillway Flow Deflector

7.3.1.4.1. Proposed Action

The SR–HC TMDL identified Brownlee Dam and HCD as the sources of elevated TDG in the HCC (IDEQ and ODEQ 2004). Since approval of the SR–HC TMDL, IPC has had the opportunity to collect new information that allowed the evaluation of spill at Oxbow Dam independent of Brownlee Dam spill (i.e., when Oxbow Reservoir forebay TDG levels were less than 110% of saturation). These data showed that when the Oxbow Reservoir forebay was below 110% of saturation, spill at Oxbow Dam increased TDG levels above the criterion in the bypassed reach (Figure 6.3-4).

Oxbow Dam is unique in that there are 2 spillways: the principal spillway along the Oregon side of the Snake River (Oxbow Dam spillway) and an emergency spillway along the Idaho side. IPC proposes to install an Oxbow Dam spillway flow deflector to reduce TDG levels and protect aquatic life. Implementation will occur consistent with the schedule in the new FERC HCC license. This schedule will accommodate FERC’s required design review process and permitting requirements. It is expected that construction and installation could be completed within 2 years of construction of the Brownlee Dam spillway flow deflectors. It may be necessary to monitor the effectiveness of the installed Hells Canyon and Brownlee dam flow deflectors before developing a CFD model to mathematically optimize the Oxbow Dam spillway flow-deflector final design. Any delay in the schedule will be vetted with the ODEQ and IDEQ for their approval and submitted to FERC for approval.

7.3.1.4.2. Proposed Design

The Northwest Hydraulic Consultants (NHC), under contract with IPC, evaluated TDG reduction structures at Oxbow Dam relative to the potential for reducing TDG levels. The distinctive geometry of the Oxbow Dam spillway presents challenges in developing structures to reduce TDG levels. Spill flows down a chute contained by training walls for a distance of 374 feet, at which point the right (east) side training wall terminates, allowing water to spill off the right side of the chute down a steeply sloping concrete face onto a concrete bench directing flow across the channel (Figure 7.3-8). The chute ends with an asymmetrical apron that generally directs spill in a downstream direction.

Figure 7.3-8
Photograph of Oxbow Dam principle spillway chute and asymmetrical spill apron (reproduced from Exhibit 7.3-6)

The NHC developed a hydraulic model to evaluate potential Oxbow Dam TDG reduction structures. Initial results indicated that a flow deflector on the sloping face at the downstream end of the existing spillway chute had sufficient potential to provide a flow regime conducive to reducing TDG levels (Exhibit 7.3-6). The conceptual design for a spillway flow deflector was developed after evaluating approximately 24 geometric refinements. The proposed Oxbow Dam spillway flow-deflector design is located along the entire side and end-sloping faces of the downstream end of the existing spillway chute (Figure 7.3-9). The flow deflector along the east side of the spillway chute has a length of about 250 feet, a width in the direction of flow of 16 feet, and an elevation of 1,691.5 feet msl. The end deflector has a length in the direction of flow of 40 feet, a width of 49 feet, and an elevation of 1,689.5 feet msl. The proposed design also incorporates a 50-foot training wall on the west side that extends downstream from the end of the spillway chute, the removal of an existing concrete fillet on the west side of the existing bench at the downstream end of the spillway chute, and the placement of an approximately 10-foot blanket thickness by a 40- to 50-foot width of riprap along the upstream 250-foot length of the east side of the spillway chute (Figure 7.3-10). IPC proposes the final Oxbow Dam spillway flow-deflector design will be quantitatively optimized and mathematically evaluated to the 7Q10 average flood flow, based on computations using a CFD model and information gained from applying a similar model to optimize deflector design at Hells Canyon and Brownlee dams. More detail on the Oxbow Dam spillway flow-deflector design is available in Exhibit 7.3-6.

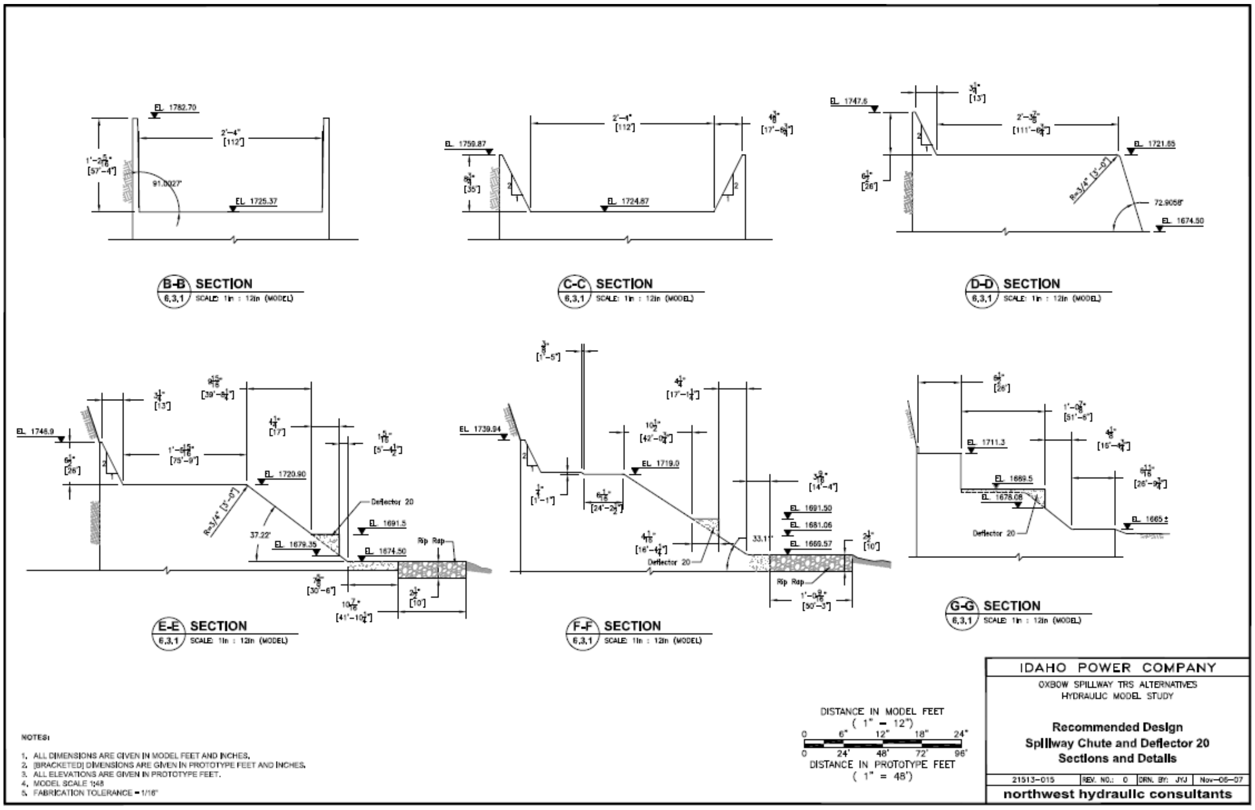


Figure 7.3-9
Plan and sectional view showing the general location of the Oxbow Dam spillway flow deflector and a detailed sectional view drawing of the proposed design (reproduced from Exhibit 7.3-6)

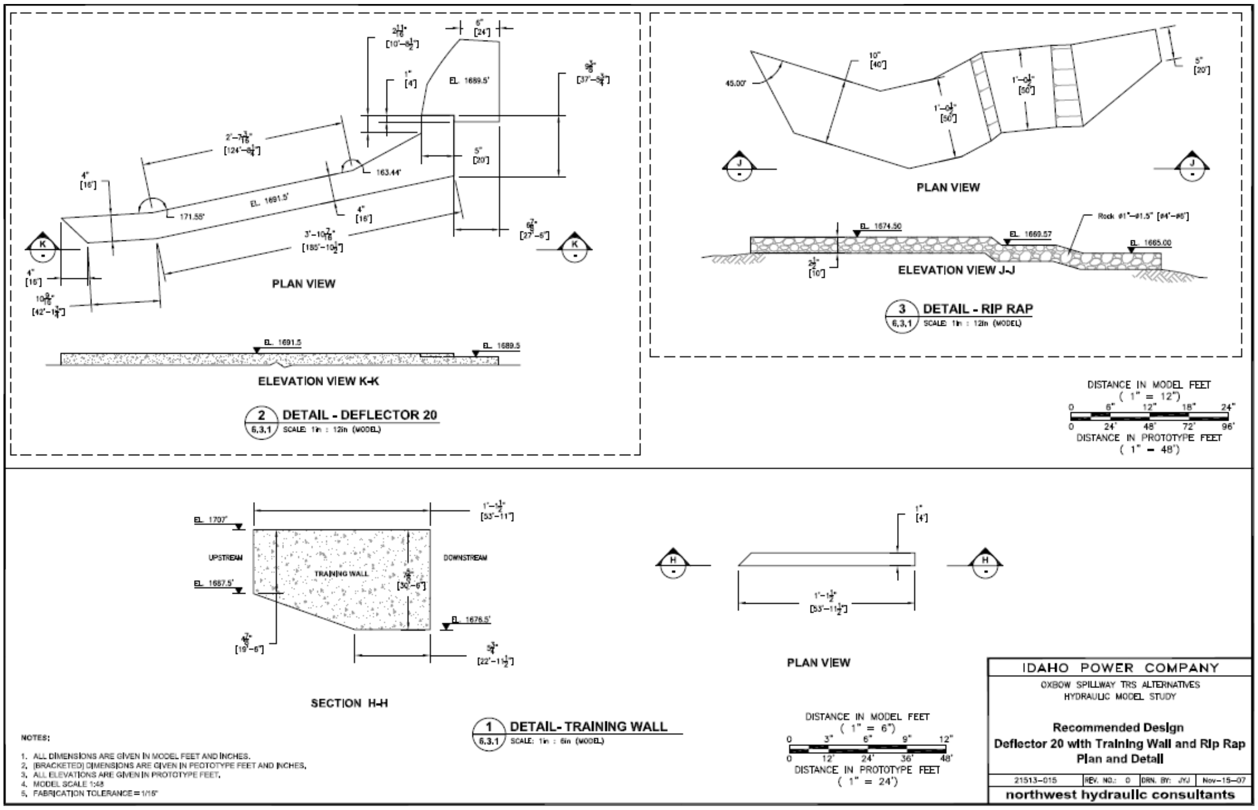


Figure 7.3-10
Plan and sectional view showing the general location of the Oxbow Dam spillway training wall and riprap and a detailed sectional view drawing of the proposed design (reproduced from Exhibit 7.3-6)

7.3.2. TDG Adaptive Measures

IPC proposes preferentially spilling water from the Brownlee Dam upper spillway gates and installing HCD sluiceway flow deflectors, Brownlee Dam spillway flow deflectors, and an Oxbow Dam spillway flow deflector as PME measures to address the SR–HC TMDL TDG load allocation and protect aquatic life. These are the best available technologies, but their performance cannot be definitively evaluated using models alone. Because the performance of these measures must be predicted either qualitatively or quantitatively, IPC proposes monitoring their effectiveness and implementing an adaptive management approach to address any potential uncertainties.

IPC concurs with the IDEQ and ODEQ (2004) that the TDG criterion is conservative for the protection of aquatic life and, therefore, the load allocation has an implicit margin of safety. If monitoring during spill indicates these PME measures fail to meet the TDG criterion and protect aquatic life, IPC will adaptively manage TDG in the HCC through the evaluation and implementation of additional PME measures designed to further reduce TDG levels.

Several additional PME measures are available for evaluation if the proposed PME measures fail to meet the TDG criterion and protect aquatic life. These include, but are not limited to, the following. Any PME measure may not necessarily be a viable measure at a particular project due to site-specific characteristics.

- **Modify the shape or location of the flow deflectors after installation to further optimize performance.** A prior knowledge of deflector performance to attain the 110% of saturation criterion is difficult with exact certainty using modeling alone. Once the deflectors are installed, it may be feasible to further investigate their performance and determine if field modifications can be made toward improvement. Some possible modifications include changing the angle of the deflector, increasing the deflector length, or slightly changing the deflector's elevation.

- **Modify or extend the training walls.** It may be feasible to extend training walls to better separate turbine and spill flows, reducing the volume of turbine flow entrained in the spill flow. This would reduce the overall volume of water that has elevated TDG levels.

    - Physical modeling of Brownlee Dam indicated turbine flow overtops the existing training wall and becomes entrained into the spillway during high spill flows (Exhibit 7.3-5). It would be possible to increase the height of this wall to preclude turbine flows from becoming entrained with the spill flows, improving the spillway flow deflectors' effectiveness.

- **Refurbish or add 1 or more units to allow for increased powerhouse hydraulic capacity.** Increasing the capacity would allow more flow to travel through the powerhouse instead of over the spillway, potentially reducing TDG levels and definitely reducing the volume of water with elevated TDG levels.

- **Modify the stilling basin or spillway apron to reduce the depth bubbles plunge.** It may be possible to modify the depth or shape of the stilling basin to reduce the depth bubbles can plunge, therefore reducing TDG levels. Some of the possible modifications may include adding concrete to the stilling basin to reduce the bottom depth, adding some type of underwater wig-walls or floors, or changing the shape of the apron lip to deflect flow upward.

- **Build an off-gassing structure downstream of the spillway.** Off-gassing structures are typically small weirs allowing for a short free fall of water and are typically constructed across the width of the river channel. These structures create conditions for the turbulent exchange of gas between the water and the atmosphere. This allows supersaturated water with high TDG levels to off-gas.

- **Construct a bypass conveyance to pass spill flows.** Water could be passed through a conveyance instead of over the spillway, and TDG levels or the volume of elevated TDG level water would be reduced.

7.3.3. TDG Reasonable Assurance

7.3.3.1. Preferential Brownlee Dam Upper Gate Spill

Spill test data were collected at Brownlee Dam during a single test conducted on June 4, 1998. The test was conducted while spilling water at 39,000 cfs, an amount greater than the 7Q10 average flood flow of 67,898 cfs when combined with the powerhouse hydraulic capacity.

An analysis of these data indicated TDG levels from the Brownlee Dam upper gate spill were statistically lower (P = <0.001) when compared to TDG levels from the lower gate spill. Figure 7.3-11 shows that TDG levels downstream of Brownlee Dam averaged 114% of saturation while spilling from the upper gates and increased during transition to spilling through the lower gates, resulting in an average TDG level of approximately 128% of saturation (Myers and Parkinson 2003).

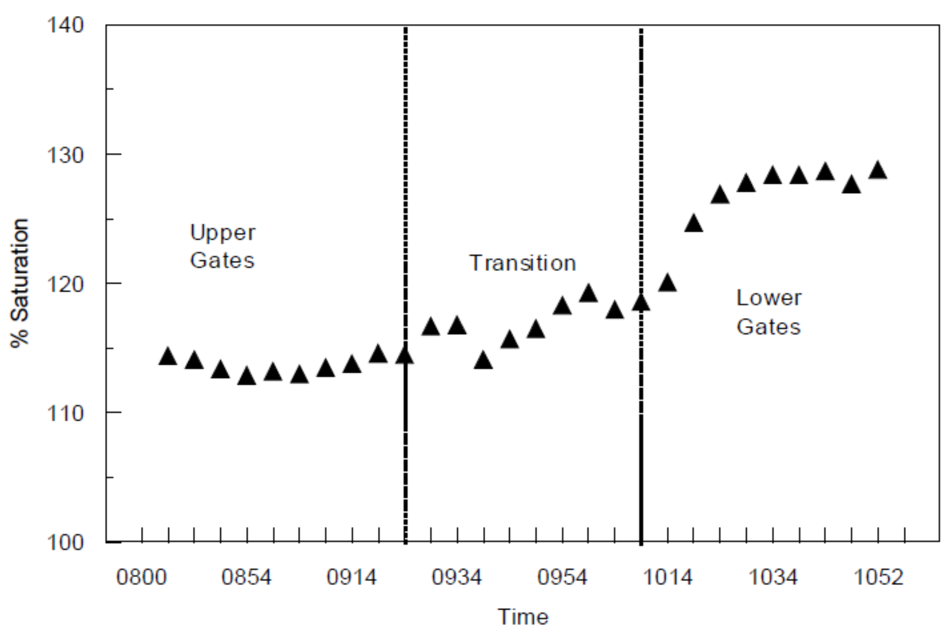


Figure 7.3-11
Measured TDG percent of saturation below Brownlee Dam during the operation of the upper and lower spillgates at 39,000 cfs

IPC's evaluation of Brownlee Dam spill test data indicated that upper gate spill resulted in lower TDG levels. IPC does not contend this preferential spill alone will attain the SR–HC TMDL load allocation; however, this measure will minimize TDG levels to the extent possible until spillway flow deflectors are installed at Brownlee Dam. Further, IPC contends that TDG levels of 114% of saturation, as measured from the upper gate spill greater than the 7Q10 average flood flow, will not have a discernible effect on aquatic life. This is supported by IPC's recent monitoring of resident fish in the HCC (Exhibit 6.3-1) and corroborated by McGrath et al. (2006) and Weitkamp (2008). All researchers reported the conclusion that short-term exposure up to 120% of saturation does not produce significant effects on resident and migratory fish when compensating depths are available.

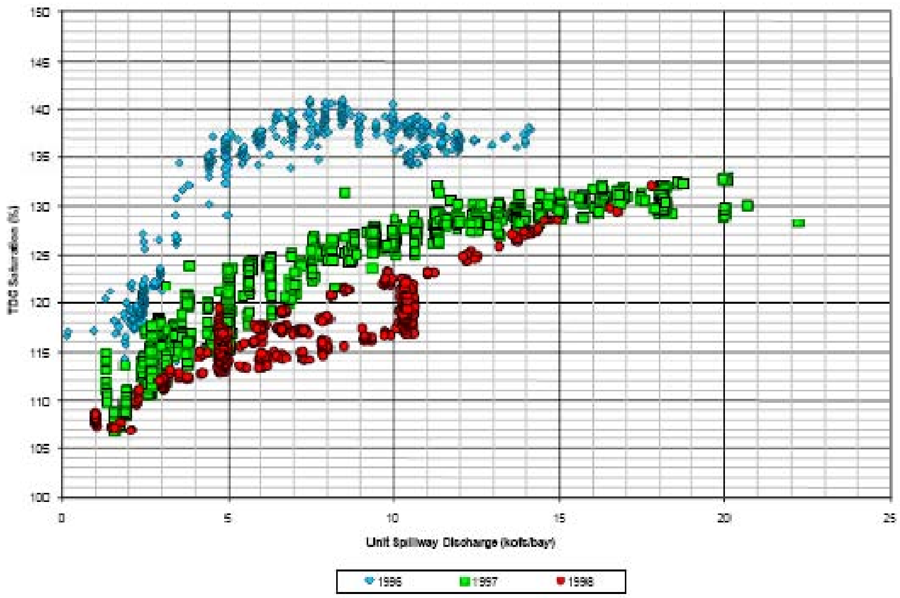
7.3.3.2. HCC Flow Deflectors

Flow deflectors are the best available technology for reducing elevated TDG levels at hydroelectric projects in the Northwest. The USACE has performed most of the research relevant to flow-deflector design, physical model studies, and initial prototype testing. The USACE evaluated numerous alternatives and concluded the best options to reduce TDG levels are to structurally modify the dam to either reduce the volume of air entrained in the water column or to reduce the hydrostatic pressures that act on entrained air by keeping entrained air near the surface (Weber et al. 2000).

The USACE evaluated several alternatives for reducing the volume of air entrained in the water column, including creating submerged spillway conduits, constructing powerhouse and spillway separation walls (training walls), converting turbines to sluices, modifying existing powerhouses to act as hydro-combine powerhouses, using submerged pressure conduits with slots, using flow through existing skeleton bays, and constructing additional powerhouse units. Each of these alternatives reduces TDG levels by preventing spilled water from contacting air. With the exception of submerged spillway conduits, each alternative adds increased structural and fish safety concerns and has significant construction costs.

The USACE also evaluated alternatives to reduce the maximum hydrostatic pressures that act on entrained air, including raising the tailrace channel and raising the stilling basin to develop surface-oriented flow. Generally, altering the tailrace channel or stilling basin involves significantly more effort and cost than implementing flow deflectors to reduce hydrostatic pressures on entrained air. Alternatives that combine the principles of reducing air volume and hydrostatic pressures include spillway deflectors, baffled-chute spillways, side-channel spillways, pool and weir channels, additional spillway bays, new spillway-gate types or openings, and v-shaped spillways. The USACE concluded the 3 most feasible alternatives for most large river dams are 1) submerged spillway conduits, 2) spillway deflectors, and 3) new spillway-gate types or openings. Of these alternatives, the installation of spillway deflectors appears the best available technology for most dams.

As a result of this type of analysis, the USACE has installed flow deflectors on many of the Lower Snake and Columbia River projects. The USACE designs deflectors for a dual purpose—to reduce TDG levels while balancing anadromous smolt passage survival rates. Because of this dual purpose, the USACE often receives waivers to exceed the 110% of saturation criterion for voluntary spill up to 120% of saturation. Likewise, TDG levels measured after the installation of flow deflectors may not represent the optimized effectiveness if only the reduction of TDG levels is the goal. At Ice Harbor Dam on the Lower Snake River, the USACE has measured TDG levels of 140% of saturation prior to the installation of flow deflectors and 130% of saturation after installation (Figure 7.3-12).



Note: No deflectors in 1996, 4 of 10 installed in 1997, 8 of 10 installed in 1998.

Figure 7.3-12
Measured TDG percent of saturation below Ice Harbor Dam, 1996–1998, with and without flow deflectors (USACE 2002)

The IIHR has evaluated flow deflectors for Rock Island Dam and Wanapum Dam, located in Grant County, Washington. Wanapum Dam, a Grant County (Washington) Public Utility District project, has had several prototype spillway deflectors installed. These data provide reasonable assurance that the 110% of saturation criterion can be met using a deflector design that results in a surface jet. The first 2 designs, a deep horizontal deflector and a deep sloping deflector, did not function optimally to meet objectives of reducing TDG levels (Table 7.3-1). The deep sloping design appears to have no observable effect on reducing TDG levels. The next iteration in Wanapum Dam deflector design was a shallow horizontal deflector. This design functioned optimally to meet objectives of reducing TDG levels (Table 7.3-2). TDG levels measured in spill from bays without deflectors reached nearly 130% of saturation (Figure 7.3-13). These levels are comparable to TDG levels measured below projects in the HCC. The shallow horizontal deflector design reduced TDG levels to the criterion of 110% of saturation or less. The proposed HCC flow-deflector designs are comparable to the Wanapum Dam shallow horizontal design.

Table 7.3-1
TDG percent of saturation levels at Wanapum Dam, Grant County, Washington, in 1998 (Weitkamp and Hagen 1999a). The 10-year, 7-day (7Q10) average flood flow is 12,916 cfs per spillway (Jeske 1999). The Wanapum Dam Powerhouse has the ability to increase flow passage, which would decrease the 7Q10 average flood flow to 8,333 cfs per bay.

Spillbay	Deflector Design	Flow (cfs)	TDG (%)
2	Deep horizontal	2,800	108–109
		6,000	109
		11,300	114–116
3	None	2,800	123–125
		6,000	128–129
		11,300	123–124
4	Deep sloping	2,800	121–122
		6,000	127–128
		11,300	122–123
5	None	6,000	123–124
		6,000	123–125

Table 7.3-2
TDG percent of saturation levels at Wanapum Dam, Grant County, Washington, in 1999 (Weitkamp and Hagen 1999b). The 10-year, 7-day (7Q10) average flood flow is 12,916 cfs per spillway (Jeske 1999). The Wanapum Dam Powerhouse has the ability to increase flow passage, which would decrease the 7Q10 average flood flow to 8,333 cfs per bay.

Spillbay	Deflector Design	Flow (cfs)	TDG (%)
2	Deep horizontal	2,800	—
		6,000	107–108
		7,500	108–110
3	None	2,800	121–122
		6,000	127–128
		7,500	—
5	Shallow horizontal	2,800	103–105
		2,800	105–106
		6,000	108–109
		6,000	108–109
		6,000	107
		7,500	109–110
		7,500	109–110

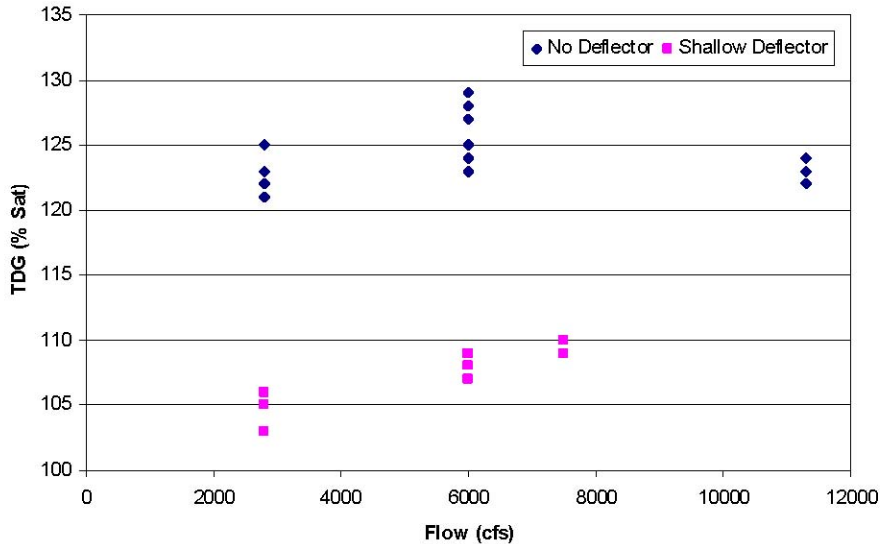


Figure 7.3-13
TDG percent of saturation (% Sat) at Wanapum Dam, Grant County, Washington, with no spillway deflector and a shallow horizontal design deflector at various flow in cfs (Weitkamp and Hagen 1999a,b)

The IIHR 3-dimensional models for HCD and Brownlee Dam were developed to qualitatively optimize flow-deflector designs to minimize air bubbles at depth (Figure 7.3-14). Currently, physical or mathematical models do not exist to conclusively predict TDG levels prior to the installation of flow deflectors. Analytical tools have recently been developed and are continually being improved to better model potential future TDG levels, but these tools have had limited field application. One such model is the IIHR CFD model, which has only been applied to Wanapum Dam but with promising results. While a CFD model will be used to optimize the final design of the HCC flow deflectors to address the TDG criterion, the only definitive way to demonstrate compliance with the 110% of saturation criterion is to implement the PME measures and monitor TDG levels during spill.

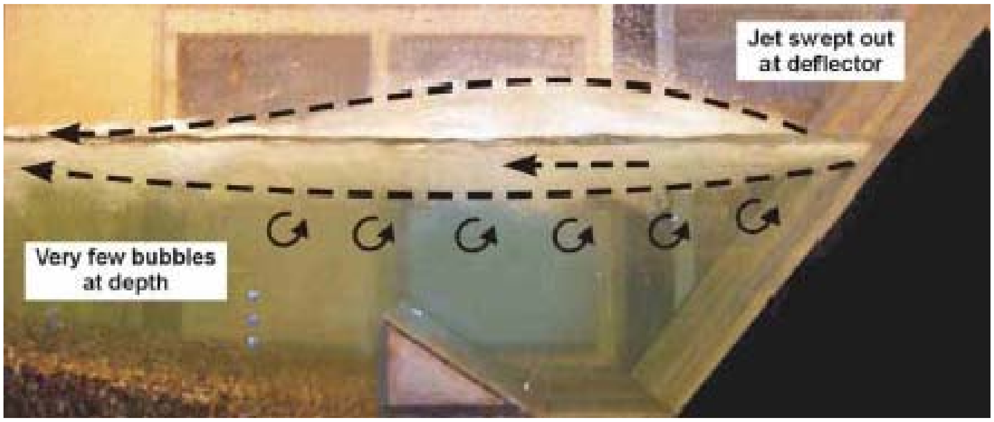


Figure 7.3-14
Sectional view photograph of a surface-jet flow regime expected from the HCD sluiceway and Brownlee Dam spillway flow-deflector designs (Weber 2005). Note the lack of observed air bubbles at depth, either in the stilling basin or downstream.

7.3.4. TDG Monitoring

As described in the SR–HC TMDL, IPC will work with the ODEQ and IDEQ as part of the HCC CWA § 401 certification to develop a TDG monitoring plan with specific compliance locations and protocol for monitoring (IDEQ and ODEQ 2004). The plan will include specific locations to define the edge of the aerated zone below each project for determining compliance with IPC's SR–HC TMDL TDG load allocation and to protect aquatic life, and a specific methodology for monitoring during spill, including equipment and the need to evaluate adaptive PME measures. Additional monitoring may be needed to collect data necessary to run a CFD model to finalize flow-deflector designs. IPC will coordinate with the ODEQ and IDEQ, as much as practicable, to develop these methods.

7.3.5. TDG Adaptive Management Schedule

Spilling at the HCC projects is almost exclusively involuntary, occurring usually as a result of flood-control constraints or high-runoff events (IDEQ and ODEQ 2004). Spilling typically occurs for short periods in higher water years when Snake River flows exceed the project's flood storage capacity, as mandated by the USACE, or the hydraulic capacity of generation turbines. Other unusual situations, including emergencies or unexpected unit outages, can induce a spill episode at any of the projects. As such, IPC is compliant with the TDG criterion and, therefore, the load allocation, in all but higher water years when spill occurs. In addition, the IDEQ and ODEQ (2004) concluded the TDG criterion is conservative for the protection of aquatic life; therefore, the load allocation has an implicit margin of safety.

IPC proposes the following schedule for the implementation of proposed PME measures. This schedule allows IPC to address the SR–HC TMDL TDG load allocations as soon as practicable based on water years for which IPC has responsibility associated with spill. There may be a need to monitor the effectiveness of PME measures prior to the final design and the implementation of successive PME measures. Monitoring must occur during higher water years when spill occurs. Monitoring will be limited to no more than 1 year before the next step is initiated. Any delay in the schedule will be vetted with the ODEQ and IDEQ for their approval and submitted to FERC for approval.

- Continue preferential spill from the Brownlee Dam upper spillway gates. This PME measure is currently in practice and will continue as part of the early implementation of CWA § 401 certification.
- Monitor during spill events, when necessary, to provide data for the CFD model development and use in the final design of PME measures as part of the early implementation of CWA § 401 certification.
- Complete the final engineering design of the HCD sluiceway flow deflectors, based on the final CFD model design, within 1 year following the issuance of the new HCC FERC license.
- Construct and install the HCD sluiceway flow deflectors consistent with the schedule in the new HCC FERC license that incorporates FERC's required design review process and

permitting requirements. It is expected these requirements could be completed within 1 to 2 years after the new license issuance. The construction and installation would occur serially during the following 2 years, likely due to ESA considerations and potential power outages. This tentatively schedules operational HCD sluiceway flow deflectors following the fourth year after the new license issuance.

- Optimize the Brownlee Dam spillway flow deflectors, based on a CFD model, evaluate performance to the 7Q10 average flood flow, and complete the final engineering design within 1 year of initiating the construction and installation of the HCD sluiceway flow deflectors. It may be necessary to monitor the effectiveness of the HCD sluiceway flow deflectors before developing a CFD model to optimize the Brownlee Dam spillway flow-deflector final design.

- Construct and install the Brownlee Dam spillway flow deflectors consistent with the schedule in the new HCC FERC license that incorporates FERC's required design review process. This tentatively schedules operational Brownlee Dam spillway flow deflectors following the sixth year after the new license issuance. Until the flow deflectors are installed, IPC will preferentially spill from the Brownlee Dam upper spillway gates as an early implementation PME measure.

- Optimize the Oxbow Dam spillway flow deflector based on a CFD model; evaluate performance to the 7Q10 average flood flow; and complete the final engineering design within 1 year of initiating the construction and installation of the Brownlee Dam spillway flow deflectors. Since Brownlee Dam TDG levels influence Oxbow Dam TDG levels, it may be necessary to monitor the effectiveness of the Brownlee Dam spillway flow deflectors before developing a CFD model to optimize the Oxbow Dam spillway flow-deflector final design to more accurately understand the dynamics of the effects of Brownlee Dam on Oxbow Dam TDG levels.

- Construct and install the Oxbow Dam spillway flow deflector consistent with the schedule in the new HCC FERC license that incorporates FERC's required design review process. This tentatively schedules the operational Oxbow Dam spillway flow deflector following the ninth year after the new license issuance. Conduct monitoring to determine if the TDG criterion is met at the edge of the aerated zone below each project and aquatic life is protected. If monitoring indicates TDG levels do not meet the criterion and protect aquatic life with the above measures implemented, adaptive steps (as described in Section 7.3.2. TDG Adaptive Measures) will be evaluated and implemented.

7.4. HAB Proposed Measures

Some blue-green algae are referred to as toxigenic, and there is the potential for exposure to HAB-related toxins during recreational activities in the HCC. Assessing the potential for the development of cyanobacterial harmful blooms and the risk posed by toxic cyanobacteria, and linking this to effective measures for the protection of public health, is complex. IPC proposes HAB monitoring in the HCC. The goal is to provide the OPHD and IDHW information for HAB-related public-health action.

7.4.1. HAB Monitoring Plan

IPC will work with the ODEQ and IDEQ as part of the HCC CWA § 401 certification to develop a HAB monitoring plan following sampling guidelines for cyanobacteria harmful blooms in recreational waters (OPHD 2015b). The plan will include sampling location and frequency, as well as specific reporting requirements to the OPHD and IDHW, including any additional sampling following the issuance of public health advisories.

Monitoring should focus primarily on the protection of human health and secondarily on the health of pets and livestock. Simple visual assessment is an important tool in recognizing the potential for the development of HABs. Monitoring will, at a minimum, consist of monthly visual assessments of HAB status, such as areas of discoloration or surface scum collection, during peak recreational periods. Figure 7.4-1 provides an index of recreational use throughout the HCC in 2013. IPC will photo-document potential HABs in areas representative of recreational use (e.g., Spring Recreation Site, Woodhead Park, McCormick Park, Oxbow Boat Launch, Copperfield Boat Ramp, and Hells Canyon Park). IPC will collect composite (consisting of 3 samples) surface grabs when a potential HAB (e.g., surface scum) is encountered for species enumeration and cell count and testing for relevant toxins. IPC will notify the OPHD and IDHW of any potential HAB and provide the monitoring results.

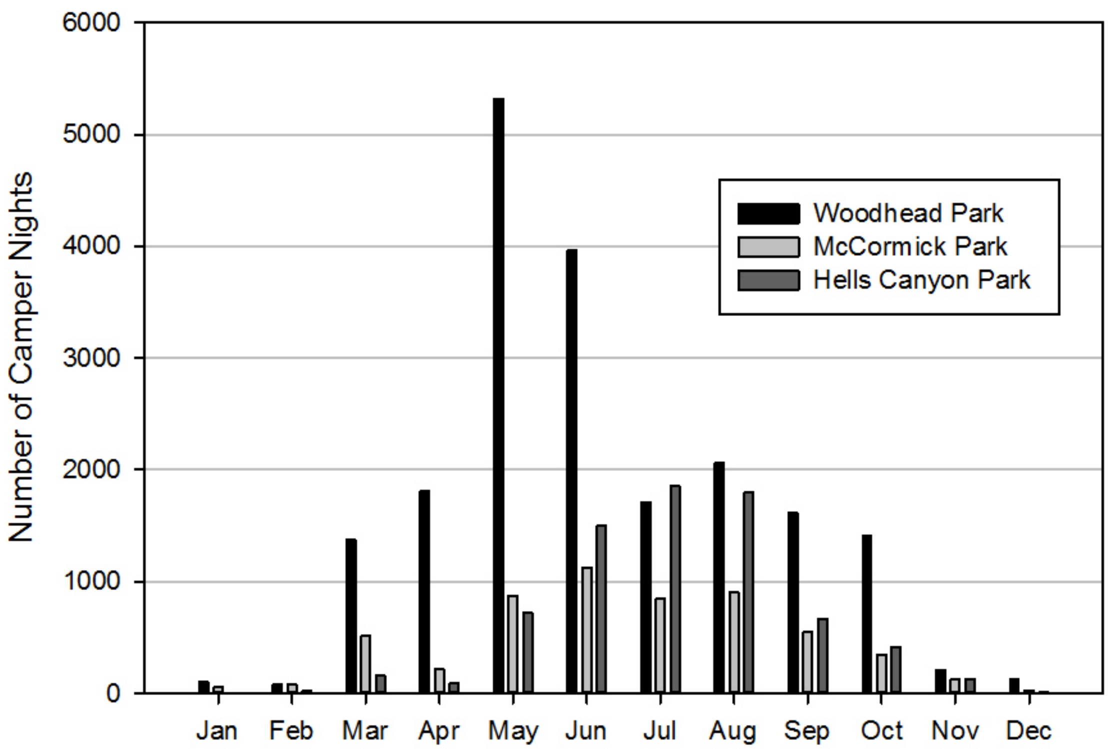


Figure 7.4-1
Index of recreational use in the HCC during 2013

IPC also proposes to adaptively manage HAB monitoring in the HCC. Previous sampling during the early 1990s (Myers et al. 2003) showed cumulative cell counts of toxigenic cyanobacteria

(Table 6.4-2) less than the OPHD health advisory guideline values (OPHD 2015a). IPC would evaluate monitoring results after 5 years and may request the modification or termination of some or all of the monitoring described in the HAB monitoring plan.

7.4.2. HAB Implementation Schedule

IPC proposes to finalize a monitoring plan within 1 year of initiation of consultation. The monitoring plan will be filed immediately following the issuance of the new HCC license from FERC for approval. Monitoring for HABs will begin immediately following FERC approval.

8. LITERATURE CITED

Adams, M. 2008. 2006 river monitoring mercury report. Boise, ID: Idaho Department of Environmental Quality, Boise Regional Office. 35 p.

Alderice, D. F., W. P. Wickett, and J. R. Bret. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. Journal of the Fisheries Research Board of Canada 35:69–75.

[APHA] American Public Health Association. 1999. Standard methods for the examination of water and wastewater. Twentieth ed. Washington, D.C.: APHA.

Arntzen, E. V., D. R. Geist, and T. P. Hanrahan. 2001. Substrate quality of fall Chinook salmon spawning habitat, Hells Canyon Reach, Snake River, Idaho. Richland, WA: Battelle Memorial Institute. Prepared for: Idaho Power Company. 40 p.

Bates, P, J. Chandler, K. Lepla and K. Steinhorst. 2014. Using mark-recapture data in an individual-based model to evaluate length-at-age differences between two Snake River white sturgeon (Acipenser transmontanus Richardson, 1836) populations in Idaho, USA. Journal of Applied Ichthyology 1-9.

Battin, T. J., and D. Sengschmitt. 1999. Linking sediment biofilms, hydrodynamics, and river bed clogging: Evidence from a large river. Microbial Ecology 37:185–196.

Bechard, M., G. S. Kaltenecker, and D. N. Perkins. 2005. Organochlorine pesticide and heavy metal contamination in the blood and feathers of bald eagles in Southern Idaho. Boise, ID: Raptor Research Center, Boise State University. 35 p.

Bell, W. H., and E. Sakshaug. 1980. Bacterial utilization of algal extracellular products. Limnology and Oceanography 25:1021−1033.

Berger, C., S. Wells and A. McCulla. 2009. The impact of Idaho Power Company’s proposed temperature mitigation projects on temperatures in the Boise River and Snake River. Technical Report EWR-02-09. Water Quality Research Group, Portland State University. 24 p

Boyd, M. S., and B. Casper. 2003. Analytical methods for dynamic open-channel heat and mass transfer: Methodology for heat source model version 7.0. 204 p.

Botelho, D. A., J. Antenucci, J. Imberger, and S. Feaver. 2003. Flux paths in Brownlee Reservoir final report. University of Western Australia. Centre For Water Research. CWR WP1819 DB. 99 p.

Botelho, D. A. and J. Imberger. 2007. Dissolved oxygen response to wind inflow interactions in a stratified reservoir. Limnology and Oceanography 52. 2027-2052.

Brandt, D., and M. Bridges. 2007. Evaluation for total mercury contamination in Brownlee Reservoir tributary streams, Snake River–Hells Canyon TMDL, Idaho and Oregon. Kellogg, ID: TerraGraphics Environmental Engineering. Prepared for: Idaho Department of Environmental Quality, State Office. 21 p.

Brennan, T., A. Campbell, A. Lehmann, and I. O'Dell. 2000. Water resources data—Idaho, water year 1999. Volume 2. Upper Columbia River Basin and Snake River Basin below King Hill. Boise, ID: U.S. Geological Survey, Water Resources Division, Idaho District. Water Data Report-ID-99-2. 440 p.

Brown, G. W. 1970. Predicting the effects of clearcutting on stream temperature. Journal of Soil and Water Conservation: 25:11 13.

Chandler, J. A., R. A. Wilkison, and T. J. Richter. 2003. Distribution, status, life history, and limiting factors of redband trout and bull trout associated with the Hells Canyon Complex. In: Technical appendices for new license application: Hells Canyon Hydroelectric Complex. Boise, ID: Idaho Power Company. Technical Report E.3.1 7; Chapter 4. 168 p.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117:1–21.

Chapman, D. W., D. E. Weitkamp, T. L. Welsh, M. B. Dell, and T. H. Schadt. 1986. Effects of river flow on the distribution of Chinook salmon redds. Transactions of the American Fisheries Society 115:537–547.

Chapra, S. C. 1997. Surface water-quality modeling. New York, NY: McGraw-Hill. 844 p.

CH2MHill. 2000. Draft Brownlee Reservoir aquatic sediment study. Boise, ID: Idaho Power Company.

Clark, G., and T. Maret. 1998. Organochlorine compounds and trace elements in fish tissue and bed sediments in the lower Snake River Basin, Idaho and Oregon. U.S. Geological Survey Water Resources Investigations Report 98–4103. 35 p.

Clark, G. M., T. R. Maret, M. G. Rupert, M. A. Maupin, W. H. Low, and D. S. Ott. 1998. Water quality in the Upper Snake River Basin, Idaho and Wyoming, 1992–1995. U.S. Geological Survey Circular 1160. 35 p.

Clayton, J. L., J. G. King, and R. F. Thurow. 1996. Evaluation of an ion adsorption method to estimate intragravel flow velocity in salmonid spawning gravel. North American Journal of Fisheries Management 16:167–174.

Cobel, D. W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of the American Fisheries Society 90:469–474.

Cole, T. M., and S. A. Wells. 2002. CE-QUAL-W2: A two-dimensional, laterally averaged, hydrodynamic and water quality model. Version 3.1 draft user manual. U.S. Army Corps of Engineers. Instruction Report EL-02-1.

Connor, W. P., H. L. Burge, J. R. Yearsley, and T. C. Bjornn. 2003. Influence of flow and temperature on survival of wild subyearling fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 23:362–375.

Driscoll, C. T., C. Yan, C. L. Schofield, R. Munson, and J. Holsapple. 1994. The mercury cycle and fish in the Adirondack lakes. Environmental Science and Technology 28:136–143.

Ebersole, J.L., P.J. Wigington, Jr, S.G. Leibowitz, R.L. Comeleo, and J. VanSickle. 2015. Predicting the occurrence of cold-water patches at intermittent and ephemeral tributary confluences with warm rivers. Freshwater Science 34:111-124.

[EPA] U.S. Environmental Protection Agency. 2001. USEPA's additions to the 1998 Idaho § 303(d) list. Seattle, WA: U.S. Environmental Protection Agency, Region X. 3 p.

EPA. 2003. EPA Region 10 guidance for Pacific Northwest state and tribal temperature water quality standards. Seattle, WA: U.S. Environmental Protection Agency, Region X, Office of Water. EPA 910-B-03-002. 49 p., plus attachments.

Essig. D. A. 2010. Arsenic, mercury, and selenium in fish tissue and water from Idaho's major rivers: A statewide assessment. Boise, ID: Idaho Department of Environmental Quality, State Office. 118 p.

Essig. D. A., and M. A. Kosterman. 2008. Arsenic, mercury, and selenium in fish tissue from Idaho lakes and reservoirs: A statewide assessment. Boise, ID: Idaho Department of Environmental Quality, State Office. 80 p.

Evermann, B. 1896. A preliminary report upon salmon investigations in Idaho in 1894. Bulletin of the U.S. Fish Commission. Volume XV for 1895, p. 253−284. Washington, D.C.: U.S. Government Printing Office.

[FERC] Federal Energy Regulatory Commission. 2007. Final environmental impact statement for hydropower license. Hells Canyon Hydroelectric Project Idaho/Oregon. FERC Project No. 1971-079. FERC/FEIS-0199F. 1,274 p.

Findlay, S. 1995. Importance of surface–subsurface exchange in stream ecosystems: the hyporheic zone. Limnology and Oceanography 40:159–164.

Findlay, S., D. Strayer, C. Goumbala, and K. Gould. 1993. Metabolism of stream water dissolved organic carbon in the shallow hyporheic zone. Limnology and Oceanography 38:1493–1499.

[FWS] U.S. Fish and Wildlife Service. 1957. A preliminary progress report on air and water temperature studies, middle Snake River drainage, 1954–1956. Portland, OR: U.S. Fish and Wildlife Service, River Basin Studies.

FWS. 1958. A preliminary progress report on air and water temperature studies for 1957, middle Snake River drainage. Portland, OR: U.S. Fish and Wildlife Service, River Basin Studies.

Fosness, R. L., J. Naymik, C. B. Hopkins, and J. F. DeWild. 2013. Water column and bed-sediment core samples collected from Brownlee Reservoir near Oxbow, Oregon, 2012. U.S. Geological Survey Data Series 809, 44 p.

Fullerton, A. H., C. E. Torgersen,J. J. Lawler, R. N. Faux, E. A Steel, T. J. Beechie, J. L. Ebersole, and S. G. Leibowitz. 2015. Rethinking the longitudinal stream temperature paradigm: region-wide comparison of thermal infrared imagery reveals unexpected complexity of river temperatures. Hydrological Processes 29:4719-4737.

Geist, D. R., C. S. Abernathy, K. D. Hand, V. I. Cullinan, J. A. Chandler, and P. A. Groves. 2006. Survival, development, and growth of fall Chinook salmon embryos, alevin, and fry exposed to variable thermal and dissolved oxygen regimes. Transactions of the American Fisheries Society 135:1462–1477.

Goldman, C. R., and A. J. Horne. 1983. Limnology. McGraw-Hill, Inc. 464 p.

Goodell, S. A. 1988. Water use on the Snake River Plain, Idaho, and eastern Oregon. U.S. Geological Survey Professional Paper 1408-E. 51 p.

Groves, P. A., and J. A. Chandler. 1999. Spawning habitat used by fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 19:912–922.

Groves, P. A., and J. A. Chandler. 2005. Habitat quality of historic Snake River fall Chinook salmon spawning locations and implications for incubation survival. Part 2: Intra-gravel water quality. River Research and Applications 21:469–483.

Groves, P. A., J. A. Chandler, and R. Myers. 2007. White paper: The effects of the Hells Canyon Complex relative to water temperature and fall Chinook salmon. Boise, ID: Idaho Power Company.

Hanrahan, T. P., D. R. Geist, and E. V. Arntzen. 2005. Habitat quality of historic Snake River fall Chinook salmon spawning locations and implications for incubation survival. Part 1: Substrate quality. River Research and Applications 21:455–467.

Hanrahan, T. P., E. V. Arntzen, F. Khan, J. R. Stephenson, P. S. Titzler, and C. Tunnicliffe. 2007. Hyporheic exchange characteristics in Snake River fall Chinook salmon spawning areas. PNWD-3847. Richland, WA: Battelle Pacific Northwest Division. Prepared for: Idaho Power Company. 50 p.

Harris, R., and C. Beals. 2013. Hells Canyon Complex mercury data assessment technical memorandum. Ontario, Canada: Reed Harris Environmental Ltd. Prepared for: Idaho Power Company. 38 p.

Harrison, J. R. 2005. Partitioning Snake River organic matter and modeling aerobic oxidation in Brownlee Reservoir, Idaho. Ph. D. dissertation. 260 p. Moscow, ID: College of Graduate Studies, University of Idaho.

Harrison, J., S. Wells, R. Myers, S. Parkinson, and M. Kasch. 1999. 1999 status report on Brownlee Reservoir water quality and model development. Draft technical report. Boise, ID: Idaho Power Company.

Harrison, J. R., D. R. Hinson, and J. Naymik. 2012. Brownlee Reservoir hypolimnion and discharge water-column toxics report. Boise, ID: HyQual. Prepared for: Idaho Power Company. 28 p., plus attachments.

Harrison, J., S. Wells, R. Myers, S. Parkinson, M. Kasch, and C. Berger. 2000. 2000 status report on southwest Snake River water quality and model development. Draft peer review report. Idaho Power Company, Boise, ID. 58 p. plus appendices.

Hoelscher, B. 2002. Evaluation of chlorophyll *a* nuisance thresholds and targets for the southwest Snake River and Brownlee Reservoir. Draft report. Boise, ID: Idaho Power Company. 16 p.

Hoelscher, B., and R. Myers. 2003. Tributary pollutant sources to the Hells Canyon Complex. Final report. In: Technical appendices for new license application: Hells Canyon Hydroelectric Complex. Boise, ID: Idaho Power Company. Technical Report E.2.2-1. 104 p.

[IDAPA] Idaho Administrative Procedures Act 58.01.02. No date. Water quality standards and wastewater treatment requirements. Boise, ID: Idaho Department of Environmental Quality, Idaho State Office. 190 p.

IDEQ. 2012. Idaho section 401 certification guidance. http://www.deq.idaho.gov/media/516305-401-certification-guidance-0912.pdf. Accessed on: March 12, 2013. 11 p.

IDEQ. 2012. Table of subbasin assessments, TMDLs, implementation plans, and five-year reviews. http://www.deq.idaho.gov/water-quality/surface-water/tmdls/table-of-sbas-tmdls.aspx. Accessed on December 24, 2012.

IDEQ. 2013. Idaho's 2010 integrated report. http://www.deq.idaho.gov/media/725927-2010-integrated-report.pdf. Accessed on: January 24, 2013.

IDEQ. 2014. Idaho's 2012 integrated report. http://www.deq.idaho.gov/media/1117323/integrated-report-2012-final-entire.pdf. Accessed on: November 28, 2014.

IDEQ and [ODEQ] Oregon Department of Environmental Quality. 2004. Snake River–Hells Canyon total maximum daily load (TMDL). Boise, ID, and Pendleton, OR: IDEQ Boise Regional Office and ODEQ Pendleton Office. 710 p., plus appendices.

[IDHW] Idaho Department of Health and Welfare. 2013. Eat fish, be smart, choose wisely: a guide to safe fish consumption for fish caught in Idaho waters. http://www.healthandwelfare.idaho.gov/Portals/0/Health/EnvironmentalHealth/FishGuide.pdf. Accessed on: June 21, 2013.

IDHW. 2014. Harmful algal blooms. http://healthandwelfare.idaho.gov/Health/EnvironmentalHealth/HarmfulAlgalBlooms/tabid/2174/Default.aspx. Accessed on: November 28, 2014.

[IDWR] Idaho Department of Water Resources. 1971. Inventory of dams in the State of Idaho. Boise, ID: Idaho Department of Water Administration, Idaho State Office. 97 p.

IDWR. 2013. Water right report. http://www.idwr.idaho.gov/apps/ExtSearch/WRAJSearch/SearchPage.aspx. Accessed: January 2015.

[IPC] Idaho Power Company. 1991. Fall Chinook interim recovery plan and study. Boise, ID: Idaho Power Company. 28 p.

IPC. 2002. Letter to T. Dombrowski regarding the December 2001 draft Snake River–Hells Canyon Total Maximum Daily Load (TMDL). Prepared by James Tucker, Senior Attorney. Boise, ID: Idaho Power Company. 7 p.

Jager, H., K. Lepla, J. A. Chandler, W. Van Winkle, A. Sullivan, R. Myers, and M. Bevelhimer. 2003. Population viability model for Snake River white sturgeon. Final report. In: K. Lepla, editor. Chapter 3, status and habitat use of Snake River white sturgeon associated with the Hells Canyon Complex. Technical appendices for new license application: Hells Canyon Hydroelectric Project. Boise, ID: Idaho Power Company. Technical Report E.3.1-6.

Jeske, D. 1999. December 13 email to Larry Weber, IIHR-Hydroscience & Engineering, Iowa City, IA: University of Iowa.

Kaplan, L. A., and J. D. Newbold. 2000. Surface and subsurface dissolved organic carbon. In: J. B. Jones and P. J. Mulholland, editors. Streams and ground waters. San Diego, CA: Academic Press.

Krabbenhoft, D. 2012. Brownlee Reservoir mercury summary May 2012 sampling results. Unpublished USGS presentation. Boise, ID.

Lancaster, S., R. Haggerty, and S. Gregory. 2005. Investigation of the temperature impact of hyporheic flow: Using groundwater and heat flow modeling and GIS analyses to evaluate temperature mitigation strategies on the Willamette River, Oregon. Final Report. Corvallis, OR: Oregon State University. 104 p.

Lay, C. 2007. Salmon Falls Creek subbasin assessment and total maximum daily loads. Twin Falls, ID: Idaho Department of Environmental Quality, Twin Falls Regional Office. 379 p.

Maier, R. M., I. L. Pepper, and C. P. Gerba. 2000. Environmental microbiology. San Diego, CA: Academic Press. 585 p.

Maret, T. R., T. A. Burton, G. W. Harvey, and W. H. Clark. 1993. Field testing of new monitoring protocols to assess brown trout spawning habitats in an Idaho stream. North American Journal of Fisheries Management 13:567−580.

Marshall, K. C. 1997. Colonization, adhesion, and biofilms. In: C. J. Hurst, G. R. Knudsen, M. J. McInerney, L. D. Stetzenbach, and M. V. Walter, editors. Manual of environmental microbiology. Washington, D.C.: American Society for Microbiology Press.

McGrath, K. E., E. Dawley, and D. R. Geist. 2006. Total dissolved gas effects on fishes of the Lower Columbia River. Prepared for: U.S. Army Corps of Engineers, Contract No. MIPR W66QKZ52991442. 15 p., plus appendix.

McHenry, M. L., D. C. Morrill, and E. Currence. 1994. Spawning gravel quality, watershed characteristics, and early life history survival of coho salmon and steelhead in five North Olympic peninsula watersheds. Sponsored by: Department of Ecology, Centennial Clean Water Act, Section 205J Clean Water Act.

Meili, M. 1997. Mercury in lakes and rivers. In: A. Sigel and H. Sigel, editors. Metal ions in biological systems. Volume 34, Mercury and its effect on environment and biology. New York, NY: Marcel Dekker. 603 p.

Miskimmin, B. M., J. W. Rudd, and C. A. Kelly. 1992. Influence of dissolved organic carbon, pH, and microbial respiration rates on mercury methylation and demethylation in lake water. Canadian Journal of Fisheries and Aquatic Sciences 49:17–22.

Mulholland, P. J., and D. L. DeAngelis. 2000. Surface–subsurface exchange and nutrient spiraling. In: J. B. Jones and P. J. Mulholland, editors. Streams and ground waters. San Diego, CA: Academic Press.

Myers, R., S. Parkinson, and J. Harrison. 1998. Tributary nutrient loadings to the Snake River, Swan Falls to Farewell Bend, March through October 1995. Boise, ID: Idaho Power Company.

Myers, R., J. Harrison, S. K. Parkinson, B. Hoelscher, J. Naymik, and S. E. Parkinson. 2003. Pollutant transport and processing in the Hells Canyon Complex. Final report.

In: Technical appendices for new license application: Hells Canyon Hydroelectric Complex. Boise, ID: Idaho Power Company. Technical Report E.2.2-2. 201 p.

Myers, R., and J. A. Chandler. 2003. Oxbow Bypass minimum flow evaluation. Revised version. In: Technical appendices for new license application: Hells Canyon Hydroelectric Complex. Boise, ID: Idaho Power Company. Technical Report E.2.3-1. 244 p.

Myers, R., and S. E. Parkinson. 2003. Hells Canyon Complex total dissolved gas study. Final report. In: Technical appendices for new license application: Hells Canyon Hydroelectric Project. Boise, ID: Idaho Power Company. Technical Report E.2.2-4.

[OAR] Oregon Administrative Rules 340-041. No date. Water quality standards: beneficial uses, policies, and criteria for Oregon. Portland, OR: Oregon Department of Environmental Quality. 87 p., plus tables and figures.

ODEQ. 2008. Temperature water quality standard implementation. A DEQ internal management directive. Oregon Department of Environmental Quality. http://www.deq.state.or.us/wq/pubs/imds/Temperature.pdf.

[ODEQ] Oregon Department of Environmental Quality. 2010. Final Oregon 2010 integrated report assessment database and 303(d) list. http://www.deq.state.or.us/wq/assessment/rpt2010/search.asp. Accessed on December 26, 2012.

ODEQ. 2012. Oregon TMDLs approved by EPA—May 2000 through December 2012. http://www.deq.state.or.us/wq/tmdls/approved.htm. Accessed on December 24, 2012.

ODEQ. 2014. Oregon's 2012 integrated report assessment database and 303(d) list. http://www.deq.state.or.us/wq/assessment/rpt2012/search.asp. Accessed on: November 28, 2014.

ODEQ. 2013. Oregon's 2010 integrated report. http://www.deq.state.or.us/wq/assessment/rpt2010/search.asp#db. Accessed on: January 24, 2013.

[OHA] Oregon Health Authority. 2013. Fish advisories: consumption guidelines. http://public.health.oregon.gov/HealthyEnvironments/Recreation/pages/fishconsumption.aspx#fishmap. Accessed on: June 24, 2013.

[OPHD] Oregon Health Authority Public Health Division. 2014. Algae Bloom Advisories. https://public.health.oregon.gov/HealthyEnvironments/Recreation/HarmfulAlgaeBlooms/Pages/Blue-GreenAlgaeAdvisories.aspx. Accessed on: November 28, 2014.

[OPHD] Oregon Health Authority Public Health Division. 2015a. Oregon harmful algae bloom surveillance (HABS) program: public health advisory guidelines. Oregon Health Authority. 23 p.

[OPHD] Oregon Health Authority Public Health Division. 2015b. Oregon harmful algae bloom surveillance (HABS) program: sampling guidelines. Oregon Health Authority. 14 p.

Park, R. A., and J. S. Clough. 2004. AQUATOX (release 2): Modeling environmental fate and ecological effects in aquatic ecosystems. Volume 2, Technical documentation. Washington, D.C.: U.S. Environmental Protection Agency.

Peterson, S. A., A. T. Herlihy, R. M. Hughes, and J. VanSickle. 2007. Mercury concentration in fish from streams and rivers throughout the western United States. Environmental Science & Technology 41(1): 58–65.

Poole, G. C., and C. H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6):787–802.

Reynolds, C. S. 1984. The ecology of freshwater phytoplankton. 1990 reprint. Cambridge, United Kingdom: Cambridge University Press. 384 p.

Richter, T. J., and J. A. Chandler. 2003. Status of fish community 1991–2000. Final Report. In: Technical appendices for new license application: Hells Canyon Hydroelectric Complex. Boise, ID: Idaho Power Company. Technical Report E.3.1 5. 256 p.

Romani, A. M., H. Guasch, I. Muñoz, J. Ruana, E. Vilalta, T. Schwartz, F. Emtiazi, and S. Sabater. 2004. Biofilm structure and function and possible implications for riverine DOC dynamics. Microbial Ecology 47:316–328.

Sawyer, A. H., M. Bayani Cardenas and J. Buttles. 2012. Hyporheic temperature dynamics and heat exchange near channel-spanning logs. Water Resources Research 48, WO1529.

Seattle Marine Laboratories. 1972. Final report: 1972 nitrogen monitoring studies. Prepared for: Idaho Power Company. 74 p.

Shumar, M., and J. de Varona. 2009. The potential natural vegetation (PNV) temperature total maximum daily load (TMDL) procedures manual. Boise, ID: Idaho Department of Environmental Quality, State Technical Services Office. 308 p.

Smith, S. G., W. D. Muir, E. E. Hockersmith, R. W. Zabel, R. J. Graves, C. V. Ross, W. P. Connor, and B. D. Arnsberg. 2003. Influence of river conditions on survival and travel time of Snake River sub-yearling fall Chinook salmon. North American Journal of Fisheries Management 23:939–961.

Soulsby, C., I. A. Malcolm, and A. F. Youngson. 2001a. Hydrochemistry of the hyporheic zone in salmon spawning gravels: A preliminary assessment in a degraded agricultural stream. Regulated Rivers: Research and Management 17:651−665.

Soulsby, C., A. F. Youngson, H. J. Moir, and I. A. Malcolm. 2001b. Fine sediment influence on salmonid spawning habitat in a lowland agricultural stream: A preliminary assessment. The Science of the Total Environment 265:295–307.

Stone, H. 2006a. Brownlee Reservoir mercury TMDL fish tissue study. Boise, ID: Idaho Department of Environmental Quality, Boise Regional Office. 9 p.

Stone, H. 2006b. Brownlee Reservoir mercury TMDL water column study. Boise, ID: Idaho Department of Environmental Quality, Boise Regional Office. 7 p.

Stumm, W., and J. J. Morgan. 1995. Aquatic chemistry: Chemical equilibria and rates in natural waters. Third ed. New York, NY: John Wiley and Sons. 1,022 p.

Thornton, K. W., B. L. Kimmel, and F. E. Payne. 1990. Reservoir limnology: Ecological perspectives. New York, NY: John Wiley and Sons. 246 p.

Urban, S. M. 2004. Water budget for the Treasure Valley aquifer system for the years 1996 and 2000. Idaho Department of Water Resources. Treasure Valley hydrologic project research report. 57 p.

[USACE] U.S. Army Corps of Engineers. 2002. Improving salmon passage: the Lower Snake River juvenile salmon migration feasibility report/environmental impact statement. Final report. Walla Walla, WA: USACE.

[USBR] U.S. Bureau of Reclamation. 1999. Lower Snake River juvenile salmon migration feasibility study and environmental impact statement. Boise, ID: U.S. Department of Interior, Bureau of Reclamation, Pacific Northwest Region.

[USGS] U.S. Geological Survey. 2003. Water-quality data webpage. http://waterdata.usgs.gov/nwis/qw. Accessed on: October 28, 2003.

Webb, W. E. 1964. General investigations in water quality. Federal aid to fish restoration job completion report. Project F-34-R-5. Boise, ID: Idaho Department of Fish and Game.

Weber, L. J. 2005. IIHR hydroscience and engineering. Iowa Institute of Hydraulic Research relative to the Hells Canyon Complex with reference to other northwest hydroelectric projects presented to the Hells Canyon Complex Settlement Working Group. 41 p.

Weber, L., P. Haug, and P. Dierking. 2000. Literature review of total dissolved gas modeling. Draft report. Iowa City, IA: Iowa Institute of Hydraulic Research, University of Iowa. 30 p.

Weitkamp, D. E. 1974. Dissolved gas supersaturation in the Columbia River system: Salmonid bioassay and depth distribution studies, 1973 and 1974. Prepared by: Parametrix, Inc., for Utility Cooperative, in care of Idaho Power Company.

Weitkamp, D. E. 2008. Total dissolved gas supersaturation summary of biological effects from literature 1980–2007. Bellevue, WA: Parametrix. 8 p.

Weitkamp, D. E., and J. E. Hagen. 1999a. Wanapum Dam spillway deflector total dissolved gas evaluation, 1998. Kirkland, WA: Parametrix.

Weitkamp, D. E., and J. E. Hagen. 1999b. Wanapum Dam spillway deflector total dissolved gas evaluation, 1999. Kirkland, WA: Parametrix.

Weitkamp, D. E., and M. Katz. 1980. A review of dissolved gas supersaturation literature. Transactions of the American Fisheries Society 109:659–702.

Welch, E. B., and T. Lindell. 1996. Ecological effects of wastewater, applied limnology, and pollutant effects. Second ed. London, UK: Chapman & Hall.

Wetzel, R. G. 2001. Limnology: lake and reservoir ecosystems. Third ed. San Diego, CA: Academic Press. 1,006 p.

Worth, D. 1994. Gradient changes in water quality during low flows in run-of-the-river and reservoir impoundments, lower Snake River, Idaho. Lake and Reservoir Management 11(3):217–224.

[WDEQ] Wyoming Department of Environmental Quality. 2012. Total maximum daily load (TMDL) development program: completed TMDL projects. http://deq.state.wy.us/wqd/watershed/TMDL/TMDL.htm. Accessed on December 24, 2012.

Zimmer, P. D. 1950. A three-year study of fall Chinook salmon spawning areas in Snake River above Hells Canyon Dam site. Portland, OR: Fish and Wildlife Service, Region 1.

Zimmerman, S., S. E. Parkinson, R. Myers, S. K. Parkinson, J. Harrison, and M. Kasch. 2002. Hells Canyon Complex Reservoir water quality modeling. Chapter 4 In: S. K. Parkinson, editor. Project hydrology and hydraulic models applied to the Hells Canyon reach of the Snake River. Technical appendices for new license application: Hells Canyon Hydroelectric Project. Boise, ID: Idaho Power Company. Technical Report E.1 4.

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